EFFICIENCY IN THE FURTHER EDUCATION SECTOR IN ENGLAND: A SUBJECT LEVEL ANALYSIS*

October 2008
Version submitted to *Economics of Education Review*

Jill Johnes, Steve Bradley and Allan Little

Department of Economics
The Management School
Lancaster University
LA1 4YX

Corresponding author: Jill Johnes
Tel: 01524 593880
Email: j.johnes@lancaster.ac.uk

* We would like to thank the Centre for Excellence in Leadership, Lancaster University Management School, for funding this research, and the LSC for providing the data. The usual disclaimer applies.

ABSTRACT

In an earlier study we established that efficiency in further education (FE) colleges varies widely. Statistical analysis suggested that student composition, such as gender, ethnic and age mix, was more important than staff composition in explaining efficiency levels. This study builds on those results by investigating efficiency levels by subject of study within FE colleges. Mean overall technical efficiency is found to vary from 75% to 86% in the worst- and best-performing subject areas, respectively. Further investigation using statistical methods indicates that, while student and teacher composition and regional characteristics affect efficiency at the subject level, their effects can vary by area of learning. This has the clear policy implication that strategies to improve efficiency in FE colleges must be devised and operated at subject rather than provider level.

Keywords: Data Envelopment Analysis, Efficiency, Further Education Sector

JEL Classification: C14; I21

1. Introduction

While the quality of provision in the secondary and higher education sectors in England has been the subject of scrutiny for some considerable time, the quality of education in the further education (FE) sector in England has been largely ignored.[1] The recently published Foster Report (2005) highlights the need for assessing the quality of FE provision, and this has been reiterated in a recent White Paper (DFES 2006), which calls for the construction of performance indicators to allow clear and meaningful comparisons between FE providers, and to create incentives for the providers to focus on the achievement and progression of their students. It is envisaged that these incentives might ultimately be strengthened by linking the information derived from the performance indicators to the distribution of funds (DFES 2006 p 69).

Performance in the FE sector has, in fact, improved in recent years (Foster Report 2005). The proportion of students achieving a qualification, known as the 'learner success rate', has risen from 59 percent in 2000/01 to 72 percent in 2003/04, whereas the retention rate, which is another key performance indicator, has remained reasonably stable at around 84 percent. Of concern, however, are the wide variations in learner success rates and retention rates between providers of further education. Thus, despite the increase nationally in the learner success rate over a 6-year period, the gap between best and worst performer has not changed (Foster Report, p23), and this therefore suggests that there are considerable variations in the efficiency with which the outputs of FE are provided.

In an earlier study of FE providers (Bradley, Johnes and Little 2008) we used Data Envelopment Analysis (DEA) to derive efficiency scores for a sample of nearly 200 FE colleges over the period 1998/99 to 2002/03. Student- and staff- related variables were used as inputs, and outputs were based on learner success and retention numbers. We found that efficiency in the sector as a whole is around 85% over the five-year period. This varies, however, from under 40% to 100%. Our analysis also investigated whether efficiency had been affected by a variety of student-related, staff-related, environmental and provider-specific characteristics.

While this earlier study provides useful insights into efficiency and productivity in the FE sector, it ignores differences in performance between subjects within and between providers. It has been shown that there are considerable differences between subjects in terms of both inputs, such as staff turnover, and outputs, such as learner success rates and retention rates (DFES 2006, p52). For example, the success rate in A level examinations in 2002/03, the typical route for entry to higher education, varies from 67 percent in Information and Communication Technology to 81 percent in

[1] The system of education in the UK is organised into four broad sectors: primary schooling, which terminates at age 11 and secondary education, completed at around the age of 16. Compulsory schooling is completed at that point. Further education typically serves students between the ages of 16-19 and is pre-degree level. Higher education serves the 18/19+ age group and is degree and post-degree level.

English (Foster Report 2005, p83). Similarly, whereas retention rates are just over 80 percent nationally, for vocational courses these are much lower at 68 percent.

This paper therefore addresses two issues. First, we calculate efficiency scores in English FE at the subject level using the learner success rate and retention rate as outputs. This part of the analysis adds to the existing literature which attempts to do the same for the secondary and higher education sectors (Yang *et al* 2002; Naylor *et al* 2000; Johnes 1997; 2006). Second, we investigate the determinants of efficiency at the subject level, adding to the much smaller literature which focuses on the higher education sector (Johnes 1997; 2006). Our analysis uses previously unused data obtained from the Learning and Skills Council (LSC) for the period 2002 and 2003. It is our view that policies to improve the efficiency of FE providers might be better developed at the subject, rather than the provider, level.

In section 2 of the paper we provide a short background on the FE sector in England, and section 3 describes the models used to derive the technical efficiency scores at subject level, and those which will be used in the multivariate analysis of these efficiency scores. The results of the analysis are reported in section 4, which is followed by a brief discussion of conclusions and policy recommendations.

2. The FE sector and the data

2.1 The FE sector

The FE sector in England comprises various types of providers. The largest group is made up of General FE and Tertiary colleges, which are large institutions offering a broad range of vocational and academic subjects at various levels, and are attended by both young people (16-19 year olds) and adults. Sixth Form colleges are another substantial group and have traditionally catered for 16-19 year olds taking academic Advanced level courses. More recently, however, they have broadened both their course offering and their student profile. Specialist Colleges concentrate on specific areas of the curriculum such as art and design, dance and drama or land based subjects. They often have well developed links with employers and industry because of the specialist nature of the subjects taught. Finally, Specialist Designated institutions cater mainly for adults, as do External Institutions. The latter, however, also cater to the needs of educationally disadvantaged students. For the purposes of this study, these two groups are amalgamated into 'External and specialist institutions'.

Most colleges derive the majority (78 percent) of their income centrally from public sources, which is distributed by the LSC since it was set up in 2001. Funding is allocated on the basis of a formula which has five components. These are a national base rate, reflecting the length and cost of

the provision of various programmes, a weighting for more costly programmes or courses, a weighting for learners achieving the programme, an uplift applied for colleges taking learners from specified disadvantaged backgrounds, and finally an additional amount paid to colleges in geographical areas where provision is more costly (eg. London). Funding in the FE sector is therefore partly based on inputs and partly tied to outputs.

2.2 The data

The data used in this analysis were obtained from the administrative records of the LSC and refer to the period 2001/02 and 2002/03. There are around 600 FE providers in England, and a record is kept, by FE college, of every qualification and their subject studied by each student. Each qualification is assigned, on the basis of its subject, to one of 14 areas of learning (AOLs).[2] These AOLs, and the broad subject areas into which they are grouped in the later analysis, are defined in the Appendix. This amounts to around 12500 observations in total (across the 2 years). However, when we link these observations to data on student and staff *numbers*, the sample falls to just under 7900 observations for nearly 400 FE providers. When these are further linked to data on student and staff *characteristics*, the sample falls again to just under 5000 observations (across nearly 350 providers).

It is a simple step to construct from this data set measures of student success by AOL and FE college: one measure is the achievement rate – the proportion of all aimed-for qualifications (within an AOL) which are actually achieved; another measure is the retention rate – the proportion of students (within an AOL) who are retained from one year to the next. Since the achievement rate is based on qualifications and the retention rate is based on students, some of whom can achieve some qualifications before dropping out, these two measures are distinct.

Descriptive statistics for achievement and retention rates are displayed by AOL and broad subject area in Table 1a. The descriptive statistics are presented for the population of colleges and AOLs (Table 1a) and for the sub-samples used in, respectively, the DEA and Tobit analyses (Table 1b). It is clear that the subject area with the lowest achievement rate is 'Science' where around 70% of the qualifications aimed for in these courses are actually achieved. In contrast, the 'Arts' experience the highest achievement rate at around 85%. These compare with an average across all subjects of 80%. The range of performance on student retention is narrower, varying from around 80% in 'Humanities' to 87% on 'Foundation' programmes, both compared to mean performance of 84%. It should be noted that the broad pattern of achievement and retention rates across AOL is

[2] The definitions of the AOLs changed in 2001/02 and therefore consistent time series data are only available from this year onwards.

similar when one compares the population and sub-sample data. This is reassuring since it suggests that there is unlikely to be any systematic bias in our analysis.

Tables 1a and 1b

In a previous paper (Bradley, Johnes and Little, 2008), we found that the efficiency scores of Specialist institutions were significantly lower, on average, than for other types of FE providers. Once the determinants of efficiency are taken into account, however, both Sixth Form colleges and Specialist institutions performed significantly worse than other types of FE colleges. However, Figures 1a and 1b show that, on the basis of these two-dimensional indicators of success, this conclusion does not hold for all subject areas (based on the DEA sample of observations)[3]. General/Tertiary FE colleges are actually the worst performers on the achievement rate (Figure 1a) relative to Sixth Form and Specialist colleges in all but 2 broad subject areas ('Humanities' and 'Foundation' programmes), where they are the second best performers. Similarly, General/Tertiary FE colleges are actually the worst performers on the retention rate in all but one subject area ('Foundation' programmes). Indeed, Specialist colleges perform best on the retention rate in 6 of the 7 broad subject areas. Whether these differences between subject areas will persist when examining the DEA efficiency scores remains to be seen.

Figures 1a and 1b

3. Methodology and models

3.1 The measurement of technical efficiency

In this paper we use DEA, a set of linear programming techniques (Charnes *et al* 1978; 1979), to estimate the technical efficiency of FE providers (as described by Farrell 1957). The deterministic and non-parametric nature of the technique means that stochastic fluctuations in the data are not allowed for, and the statistical significance of the inputs and outputs in the production process cannot be measured. It is nevertheless an attractive tool in our context because it allows for both multiple outputs and multiple inputs, without requiring either knowledge of input or output prices, or an assumption of profit maximisation or cost minimisation on the part of the FE providers (Coelli and Perelman 1999). Furthermore, DEA allows each unit to choose its own input and output weights to show it at its best. In the context of FE, where institutions are highly diverse and may choose to have different priorities regarding inputs and outputs, this is an attractive feature, and

[3] Note that figures for External and specialist institutions are not shown because of the small numbers in this category.

makes DEA a superior technique to, for example, regression or stochastic frontier analysis where the same input and output parameters are applied across all observations in the data set. For these reasons, DEA is the technique of choice in this context. A full discussion of the technique is presented in Johnes (2004), and so here we provide a brief overview.

Consider a decision making unit (DMU *k*) which produces *s* outputs from *m* inputs. Below are the linear programming models which need to be solved to calculate the DEA efficiencies of all DMUs in the sample under the assumption of constant returns to scale (CRS).

$$\text{Maximize} \qquad \phi_k + \varepsilon \sum_{r=1}^{s} s_r + \varepsilon \sum_{i=1}^{m} s_i \qquad (1)$$

$$\text{Subject to} \qquad \phi_k y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} + s_r = 0 \qquad r = 1,\ldots,s \qquad (2)$$

$$x_{ik} - \sum_{j=1}^{n} \lambda_j x_{ij} - s_i = 0 \qquad i = 1,\ldots,m \qquad (3)$$

$$\lambda_j, s_r, s_i \geq 0 \qquad \forall j = 1,\ldots,n; r = 1,\ldots,s; i = 1,\ldots,m$$

where y_{rk} is the amount of output *r* used by DMU *k*; x_{ik} is the amount of input *i* used by DMU *k*; and s_r, s_i are the output and input slacks, respectively. Overall technical efficiency of DMU *k* is measured by $1/\phi_k$; DMU *k* is efficient if its efficiency score is 1 and all slacks are zero.

DEA requires the specification of a full set of inputs and outputs. One well-known disadvantage of the technique, however, is that the degree of discrimination between DMUs is lower the more variables are included, and so a parsimonious DEA model is to be preferred (Bradley, Johnes and Millington 2001). Some studies have therefore taken a two-stage approach whereby some variables are held back from the DEA and used in a second stage statistical analysis as possible explanatory variables of the efficiency scores (Ray 1991; McCarty and Yaisawarng 1993; Lovell *et al* 1994; Duncombe *et al* 1997; Kirjavainen and Loikkanen 1998; Mancebon and Mar Molinero 2000; Ramanathan 2001; Grosskopf and Moutray 2001; Bradley, Johnes and Millington 2001; Bratti 2002; Bradley, Johnes and Little, 2008). The underlying assumption of the two-stage approach is that the variables in the second stage affect the *efficiency* with which outputs are produced from the inputs, and this forms the basis of the decision of which variables to include in the first stage and which to include in the second stage. It has become standard practice to specify in the DEA those inputs which are largely under the control of the DMU, while factors which are beyond their control are reserved for a second stage analysis of the efficiency scores (see section 3.2)

Our DEA is conducted at the level of the AOL, and so each AOL (within an FE college) can be thought of as a DMU. Generally speaking, FE providers take raw materials (students) and convert these (using teachers) into qualified students. We therefore specify a simple DEA model as follows:

Inputs:

$TEACH_{ij}$ the total number of teaching staff in each FE college *i*, AOL *j* (*j* = 1,…,14)

$STUD_{ij}$ the total number of students in each FE college *i*, AOL *j* (*j* = 1,…,14)

Outputs:

$RETNUM_{ij}$ the number of retained students in FE college *i*, AOL *j* (*j* = 1,…,14)

$ACHV_{ij}$ the number of aimed-for qualifications which are actually achieved in FE college *i*, AOL *j* (*j* = 1,…,14).

The inputs to the FE production process therefore reflect quantity, while the quality of the inputs is ignored. Variables reflecting student and teacher quality are therefore considered for inclusion in the second stage analysis of the efficiencies.

3.2 Multivariate analysis of the factors affecting efficiency

The socio-demographic composition of the student population can be expected to affect the efficiency of FE colleges and their constituent departments. For example, the educational attainment of girls is higher than that for boys in FE, particularly in academic subjects (Andrews, Bradley, Stott and Taylor 2006), and girls are also less likely to drop out (Bradley and Lenton 2007). Subject variations are likely, however, insofar as boys tend to choose, and do relatively better in, mathematics-based subjects, whereas girls do better in English, humanities and languages (Andrews, Bradley, Stott and Taylor, 2006). In addition, young people from ethnic minority backgrounds tend to stay on in FE to close the so-called 'qualification gap' and prefer to do so through academic rather than vocational courses (Bradley and Taylor 2004), and are less likely to drop out. Socio-economic background is also known to affect student achievement (Bradley and Taylor 2004; Andrews, Bradley, Scott and Taylor 2006; Bradley and Lenton 2007), although less so at the post-compulsory schooling stage. The percentage of students in each AOL (for AOLs 1 to 14) who do not qualify for widening participation uplift factor is included as a measure of socio-economic background .

The environmental or socio-demographic characteristics of the locality in which the FE provider is located can also be expected to affect its efficiency. The local unemployment rate is

included because it may increase the FE provider's efficiency score via its effects on student attainment and particularly student retention. A high rate of unemployment may encourage students to stay on, rather than drop out, because opportunities in the labour market are scarce (a discouraged worker effect), and it may lead to higher attainment insofar as students work harder to secure a job once they complete FE. These effects may be particularly strong for students on courses, such as 'Vocational trades' through to 'Personal services', since they have a more explicit focus on preparing students for entry to the labour market after their course has been completed. The percentage of the local population with no qualifications is also included to capture the effect of family background. This is crude but it is expected that localities with a high proportion of unqualified adults will have students from low income families. Students from these backgrounds are more likely to drop out and have lower educational attainment (Bradley and Lenton 2007; Bradley and Taylor 2004).

The size of department, measured by the number of students in each AOL (AOLs 1 to 14), may affect overall efficiency within the subject area. The size of the AOL and its square are included to check whether there are any scale effects, which are not taken into account in the CRS models. Subject areas with more teachers are more likely to specialise in teaching particular aspects of the curriculum, which feeds through to higher attainment and retention rates. In addition, the size of the FE provider within which the AOL is located may affect efficiency, insofar as larger providers are more able to offer support services, library and computing facilities since funding per student tends to be higher. Thus the size of the college and its square are also included.

We also construct a number of variables relating to the quality of the staff in the colleges, such as their average age and experience; more experienced staff should be better teachers and hence raise attainment, whereas older teachers may be less attuned to the needs of their students which have the consequence of reducing retention rates. The 'fit' between the background of staff and those of students is also explored by including the ratio of teachers from a particular ethnic background to the student equivalents. Insofar as teachers from the same ethnic group can more easily empathise with students from the same ethnic group, and given their greater cultural awareness of the needs of this group of students, one might expect a higher ratio to feed through to better exam results and increased retention.

It is possible that there may be temporal variations in efficiency that are not controlled for by the time varying covariates described above, therefore we also include year dummies in our tobit models. Similarly, there be broad institutional differences in efficiency that are unaccounted for by the staff and student composition variables, hence the type of FE provider is also included in our models.

We use a tobit model to explore the correlates of efficiency because of the bounded nature of the DEA efficiency scores.

Tables 2a and 2b provide a summary of the data included in the DEA and statistical models respectively. It should be noted that the number of observations differ between the two samples and hence there is some discrepancy between the two tables in terms of AOL size (measured in terms of student numbers). Both samples suggest, however, that average size varies substantially between AOLs: 'Vocational trades' is the smallest subject area while 'Business & related' is the largest subject area (see Tables 2a and 2b). It is of interest to note in Table 2b that the subject area with the smallest number of students (on average) has the largest average provider size. Thus the 'Vocational trades' are not only small in absolute terms but also relative to the size of the college in which it is located. 'Business & related', on the other hand, has a relatively low mean provider size.

Tables 2a and 2b

There is a large variation in both gender and ethnic mix of the students by AOL. 'Construction' and 'Engineering' (both AOLs are within the 'Vocational trades' subject area), which are traditionally male oriented subjects, attract only 6% and 12% of females, respectively, and this compares with an average of 56% of females students across all AOLs. At the other end of the spectrum, 'Health' and 'Hairdressing' (both AOLs are within the 'Personal services' subject area) attract 70% and 88% of females respectively. The AOLs in the broad subject area of 'Vocational trades' seem to attract a below average percentage of students from ethnic minorities, while the converse is the case for 'Foundation' programmes. The latter AOL is also remarkable for having the lowest percentage of students who do not qualify for widening participation uplift factor, and the highest percentage of students with learning disabilities.

As expected, there is little variation across subject areas in the variables relating to the local environment in which the provider is located. In contrast, there is considerable variation in the percentage of teaching staff on permanent and fixed term contracts with the 'Science' AOL having an above average percentage. In addition, the ratio of students to staff varies from below 50 in 'Business' to above 300 in 'Information and communication technology', suggesting the presence of substantial scale economies in the latter area.

4. Results

4.1 Subject variations in technical efficiency

The results of applying an output-oriented DEA with CRS, using the software package PIM DEAsoft V2, to the sample data for 2002 and 2003 are summarised in Table 3.[4] The gap between the worst- and best-performing AOLs is around 13 percentage points, on average. 'Health' is the AOL with the lowest mean effcieincy at almost 72%. The broad subject area 'Personal services' of which 'Health' is a part has a generally low average efficiency at 75%. This result is unexpected insofar as student achievement and retention in 'Health' (and, indeed, the 'Personal services' subject area generally) are very high (see Table 1). In contrast, the best-performing broad subject area (in terms of DEA efficiency) is the 'Arts', which may benefit from having a relatively low student-staff ratio (see Table 2b). We also computed equivalent efficiencies for the Tobit sample and these were almost identical to those reported in Table 3.

Table 3

Earlier work established a significant difference in the performance of the different types of FE provider (Bradley, Johnes and Little 2008). Table 4 shows that, on average, and for all subject areas combined (see Table 4, note 1 for an explanation), Sixth Form colleges are around 8 percentage points more technically efficient than General and Tertiary FE colleges, and around 11 percentage points more efficient than Specialist colleges. Moreover, Table 4 offers evidence that differences in the performance of specific groups of colleges persist even at broad subject area level. Sixth Form colleges are top performers in all but two subject areas, the exceptions are 'Humanities' and 'Foundation'. In these two subject areas, Specialist colleges are the best performers. General and Tertiary FE colleges are therefore consistently poor performers in all subject areas.

Table 4

4.2 The determinants of technical efficiency: Evidence from a pooled model

The variation in efficiency by AOL and by type of FE provider requires further investigation, and the results of this are displayed in Table 5. The first result of note is that student characteristics, such as gender, age, ethnic origin, and socio-economic status are strongly related to

[4]DEA was applied separately to data for 2002 and 2003. The pure (VRS) technical efficiencies were also generated and are available on request.

the overall (CRS) technical efficiency score. Indeed, if the 9 student-related variables are excluded from the overall technical efficiency model (model 2 in Table 5), the chi-squared falls by 317.05. [5]

With regard to student gender, a 10 point increase in the percentage of female students increases overall technical efficiency by between 1.1 and 1.8 percentage points, depending on whether or not we exclude teacher characteristics. The ethnic background of students is also a significant determinant of overall technical efficiency: the larger the percentage of students from an Indian background the higher the technical efficiency of the FE provider. Students from a minority ethnic background, and especially the Indian group, may work harder at college to close the achievement gap between themselves and their white counterparts to offset expected discrimination once they enter the labour market. Insofar as this greater effort leads to a lower drop-out rate and higher achievement rate amongst these groups, the outcome is greater efficiency. Socio-economic status also has a positive effect on efficiency: an increase in the percentage of students from more prosperous home backgrounds, reflected by the percentage of students ineligible for the widening participation funding, increases technical efficiency. In contrast, a higher percentage of mature students (aged 19 or over) reduces the technical efficiency of the FE provider. This effect may arise because mature students face greater financial constraints, which means that maintaining a presence at college is more difficult to achieve.

Turning now to environmental variables, which reflect the geographical location of the college, the unemployment rate, as expected, has a positive effect on efficiency. Thus, a 1 point increase in the local unemployment rate increases overall technical efficiency by 0.3 percentage points. One plausible explanation is that a higher unemployment rate in the locality signals to students that there are fewer job opportunities in the labour market, which has the effect of reducing the drop out rate and stimulates increased attainment. The education level of the adult population of the local area, which acts as a proxy for the socio-economic composition of the catchment area of the college, has no statistically significant effect.

There is little evidence that scale matters insofar as the coefficient estimates for AOL size and College provider size are small. Provider type, however, is highly significantly related to efficiency. Sixth Form colleges have higher technical efficiency scores by around 4 percentage points when compared to General/Tertiary colleges. This is a little smaller than the gap in raw efficiency scores observed in Table 4, reflecting the effect of differences in student, teacher and environmental characteristics. Specialist colleges, on the other hand, have overall efficiency levels which are on average between 3 and 6 percentage points lower than General and Tertiary FE colleges (compare models 1 and 2). This is much larger than the gap observed in the raw efficiency levels (Table 4).

[5] The results are similar for pure (VRS) technical efficiency, with a fall in chi-squared of 347.76. The results are available on request from the authors.

The focus of this paper is upon variations in efficiency scores by subject area. What is clear from Table 5 is that, even after taking into account a host of variables which vary at the subject level, additional effects are picked up by the subject area dummy variables. Furthermore, these variables are very important determinants of provider efficiency in terms of statistical significance and magnitude. In the cases of 3 subject areas ('Personal services', the 'Arts' and the 'Humanities') the difference in efficiency scores relative to 'Science', the base case, is largely the same as that observed in Table 4. For the remaining 3 subject areas, this is not the case. Controlling for other factors the efficiency scores of 'Vocational trades', 'Business & related' and 'Foundation' programmes are now higher than for 'Science' courses (see Table 4). In the case of 'Vocational trades', efficiency is 8.5 percentage points higher than in 'Science' subjects once both student- and teacher-related variables are taken into account. Why these subject level variations occur requires a disaggregated analysis for each broad subject area, which we turn to in the following section.

Model 2 in Table 5 includes teaching-related variables, the consequence of which is to reduce our sample size. Note, however, that apart from those variables highlighted above, there is little effect on other covariate estimates. Also, as a block the teaching variables are important determinants of differences in AOL efficiency. The change in chi-squared from excluding the 11 teaching-related variables from our model is 243.55, suggesting that teaching variables are as important as the student-related variables.

The most statistically significant teacher-related variable affecting technical efficiency is the ratio of students to teachers which has a non-linear effect. The result suggests that increasing class size has a positive effect within the range of student to staff ratios observed in the sample data. Moreover, this result remains even when AOL and provider size are dropped from the equation, suggesting that the result is not simply caused by correlation between the various size variables: class, AOL and provider size. This is a somewhat surprising result insofar as one expects there to be a negative and linear effect between class size and academic attainment, although there is evidence in the context of Finnish upper secondary education (age 16 to 19 year olds) of a negative relationship between class size and *in*efficiency which is consistent with the finding here (Kirjavainen and Loikanen 1998).

The average age of teachers is negatively related to technical efficiency up to an age of 39 years, after which efficiency rises with age. In contrast, the experience variables are statistically insignificant. Possible multicollinearity between age and experience was investigated by dropping the experience variables, but the result remained unchanged. Many of the other teaching variables are statistically insignificant.

4.3 A disaggregated analysis by AOL

The limitation of the results in the previous section is that we assume that the nature of the production process in each subject area is identical, except for a shift given by the broad subject dummy variables. In this section we present the results of performing the analysis separately for each broad subject area and these are displayed in Table 6. Several interesting findings emerge. The degree of success with which inter-institutional variations in efficiency can be explained by student-, staff- and institution-related variables differs greatly by subject area. The chi-squared statistic (with 29 degrees of freedom) varies from 84 in 'Foundation' programmes to 476 in 'Humanities', suggesting greater success in explaining efficiency scores in the latter compared to the former.

Student-related characteristics are generally important explanatory variables, but their magnitude and statistical significance varies considerably by subject area. A higher percentage of female students has a statistically significant positive effect on overall efficiency in all but 2 broad subject areas, namely, 'Science' and the 'Arts'. The largest effects are observed for the 'Business & related' and 'Personal service' subjects, where a 10 percentage point increase in the percentage of females in the subject increases technical efficiency by 2.4 and 2.2 percentage points, respectively. The effect of the ethnic minority variables also differ by broad subject area. Many of the estimates for the Pakistani/Bangladeshi and Other ethnic groups are statistically insignificant, whereas there are some interesting findings with respect to the percentage of Black and Indian students. In the case of 'Personal services', the 'Arts' and to a lesser extent 'Business & related' subjects the effect of a higher percentage of Black students on technical efficiency is positive; in the 'Humanities' area, however, the effect on technical efficiency is negative but borderline significant. A higher percentage of Indian students raises efficiency in all subjects but is statistically significant in only half the broad subject areas. It is likely that these results reflect differences in the prior attainment of students from each ethnic group with Indians typically ranked highest followed by Black and Pakistani/Bangladeshi students.

The percentage of mature students has a significantly negative effect on efficiency in many of the subject areas, except for the 'Arts'. This effect is particularly large ($\boldsymbol{\beta}$ = -0.15) in 'Business & related' and 'Humanities' subject areas. The family background of students is also important insofar as a higher percentage of students from 'wealthier' backgrounds, reflected by the non-widening participation variable, the higher the technical efficiency of the subject area. This is particularly the case in 'Business & related' and 'Personal service' subject areas. In contrast, environmental factors, such as the unemployment rate are generally statistically insignificant in explaining efficiency within broad subject areas, the exception being the 'Humanities' and 'Science' subjects where it has a large positive effect.

The size of the AOL varies in the direction of its effect on technical efficiency. Size has a negative effect on efficiency in 'Vocational trades', 'Business & related' and 'Personal services', but a positive effect in the 'Arts' and 'Humanities' programmes. The significance of the square of AOL size in the case of the last two suggests that the optimum size of AOL within these 2 broad subject areas is around 3500 in each case. This is around 2 to 3 times larger than their current average size. The evidence regarding the effect of provider size on efficiency is limited. Provider size is significantly negatively related to efficiency in 'Science'. The optimal provider size for this subject area is estimated to be 21,800, which is almost twice the current average size.

Sixth Form colleges perform significantly better than General/Tertiary FE colleges in 4 subjects - 'Science', 'Personal services', the 'Arts' and 'Humanities' subject areas. In these cases technical efficiency is between 2 and 5 percentage points higher in Sixth Form colleges compared to General/Tertiary FE colleges. Specialist colleges have lower technical efficiency scores in 'Personal service' subjects, by around 15 percentage points when compared with General/ Tertiary FE colleges.

Teaching-related variables play a much smaller role in explaining efficiency levels within each subject area. Indeed, in the 'Arts', no teaching-related variables are statistically significant. In contrast, the student-teacher ratio is positively related to efficiency in 3 broad subject areas: 'Science', 'Personal services' and 'Humanities' The average age of teachers has a negative and statistically significant effect in 'Vocational trades', and to a lesser extent the 'Humanities' subjects. The significance of the squared terms suggests that efficiency starts to rise with teacher age in these subject areas after an age of 43 to 44 years. In contrast, teacher age has a significantly positive effect in 'Foundation' programmes up to an age of 44 years, after which efficiency falls with age. Surprisingly, teacher experience has no significant effect on efficiency in any subject area. Possible interactions between teacher age and experience are investigated by dropping the age variables, but experience remains insignificant.

5. Conclusion

The results of an earlier analysis of efficiency in English FE which took no account of differences between subjects concluded that FE providers need to implement strategies for improving achievement and retention amongst the most at-risk students, namely white males (Bradley, Johnes and Little 2008). There is some evidence in the context of higher education, however, that the determinants of achievement and retention vary by subject of study (Johnes 1997; 2006). The effectiveness of strategies devised to increase the efficiency with which FE colleges provide education is likely to be improved, therefore, by investigating whether there are also differences between subjects in the efficiency of FE colleges. To this end, we calculated, using

DEA, the overall technical efficiency scores across 14 AOLs in the English FE sector using data for 2002 and 2003 obtained from the LSC. The results of the DEA confirmed that there are differences in performance by AOL: the mean overall technical efficiency score varied from 75% in 'Health, social care & public services' to 86% in 'Visual and performing arts and media'.

A statistical analysis of the DEA efficiency scores suggests that student-related characteristics such as gender, age, ethnic origin and socio-economic status are important determinants of technical efficiency. Some teacher-related variables such as the ratio of students to staff and the age of teachers are also significant in explaining efficiency. Environmental variables play a much smaller role in explaining efficiency, the only significant variable being the local unemployment rate which has a positive effect on efficiency. Even taking all these variables into account, however, there remain some significant differences in efficiency between broad subject areas.

Further analysis by broad subject area provides evidence that the precise effects of student-, teacher- and institution-related variables vary by subject. These results therefore suggest that strategies for improving efficiency should be developed at the micro (subject) rather than the macro (provider) level, since the variables which are important in explaining efficiency vary significantly by subject. Thus, concentrating on improving achievement and retention amongst white males (the strategy implied by the results of analysis at the provider level) may have little effect on improving efficiency in, for example, 'Arts' or, to a lesser extent, 'Science' where student gender appears to have little effect on performance, or in 'Vocational trades' where ethnic background has no effect on efficiency. FE managers therefore need to look at each subject area separately and decide on policies which will improve efficiency in that specific subject. In addition, the existence of differences in efficiency between types of FE provider at the subject level suggests that it is vital that further investigation should be undertaken to establish the specific characteristics of each type of college which contribute to increased efficiency.

References

Andrews M, Bradley S, Stott D and Taylor J. The evolution and determinants of the educational gender gap in England. Mimeo, Department of Economics, Lancaster University; 2006.

Bradley S, Johnes G and Millington J. The effect of competition on the efficiency of secondary schools in England. European Journal of Operational Research 2001;135; 545-568.

Bradley S, Johnes J and Little A. The measurement and determinants of efficiency and productivity in the further education sector in England. Bulletin of Economic Research (forthcoming); 2008.

Bradley S, Johnes J and Little A. The Measurement and Determinants of Efficiency and Productivity in the FE Sector in England. Report to the Centre for Excellence in Leadership, Lancaster University Management School; 2006.

Bradley S and Lenton P. Dropping out of post-compulsory education in the UK: An analysis of determinants and outcomes. Journal of Population Economics 2007;20(2); 299-328.

Bradley S and Taylor J. Ethnicity, educational attainment and the transition from school. The Manchester School 2004;72; 317-346.

Bratti M. Does the choice of university matter? A study of the differences across UK universities in life sciences students' degree performance. Economics of Education Review 2002;21; 431-443.

Charnes A, Cooper W W and Rhodes E. Measuring the efficiency of DMUs. European Journal of Operational Research 1978;2; 429-444.

Charnes A, Cooper W W and Rhodes E. Measuring the efficiency of decision making units: a short communication. European Journal of Operational Research 1979;3(4); 339.

Coelli T and Perelman S. A comparison of parametric and non-parametric distance functions: with application to European railways. European Journal of Operational Research 1999;117; 326-339.

Department for Education and Science. Further Education: Raising Skills, Improving Life Chances. White Paper: London; 2006.

Duncombe W, Miner J and Ruggiero J. Empirical evaluation and bureaucratic models of inefficiency. Public Choice 1997;93; 1-18.

Farrell M. The measurement of productive efficiency. Journal of the Royal Statistical Society A 1957;120; 253-281.

Foster Report. Realising the Potential: A Review of the Future Role of Further Education Colleges. Department for Education and Science: London; 2005.

Grosskopf S and Moutray C. Evaluating performance in Chicago public high schools in the wake of decentralization. Economics of Education Review 2001;20; 1-14.

Johnes J. Inter-university variations in undergraduates non-completion rates: a statistical analysis by subject of study. Journal of Applied Statistics 1997;24(3); 343-361.

Johnes J. Efficiency measurement. In: Johnes G and Johnes J (Eds), International Handbook of the Economics of Education. Edward Elgar: Cheltenham; 2004. p. 613-742

Johnes J. Measuring efficiency: a comparison of multilevel modelling and DEA in the context of higher education. Bulletin of Economic Research 2006;58(2); 75-104.

Kirjavainen T and Loikkanen H A. Efficiency differences of Finnish senior secondary schools: an application of data envelopment analysis and Tobit analysis. Economics of Education Review 1998;17; 377-394.

Lovell C A K, Walters L C and Wood L L. Stratified models of education production using modified data envelopment analysis and regression analysis. In: Charnes A, Cooper W W, Lewin A Y and Seiford L M (Eds), Data Envelopment Analysis: Theory, Methodology and Applications. Kluwer Academic: Dordrecht; 1994. p. 329-351.

McCarty T A and Yaisawarng S. Technical efficiency in New Jersey school districts. In: Fried H O, Lovell C A K and Schmidt S S (Eds), The Measurement of Productive Efficiency. Oxford University Press: Oxford; 1993. p. 271-287

Mancebon M J and Mar Molinero C. Performance in primary schools. Journal of the Operational Research Society 2000;51; 843-854.

Naylor R , Smith J and McKnight A. Occupational earnings of graduates: evidence for the 1993 UK university population. Department of Economics, University of Warwick; 2000.

Ramanathan R. A data envelopment analysis of comparative performance of schools in the Netherlands. Opsearch 2001;38; 160-182.

Ray S C. Resource use efficiency in public schools: a study of Connecticut data. Management Science 1991;37; 1620-1628.

Yang M, Goldstien H, Browne W and Woodhouse G. Multivariate multilevel analyses of examination results. Journal of the Royal Statistical Society A 2002;165(1); 137-153.

Figure 1a: Achievement rate by broad AOL and type of FE institution

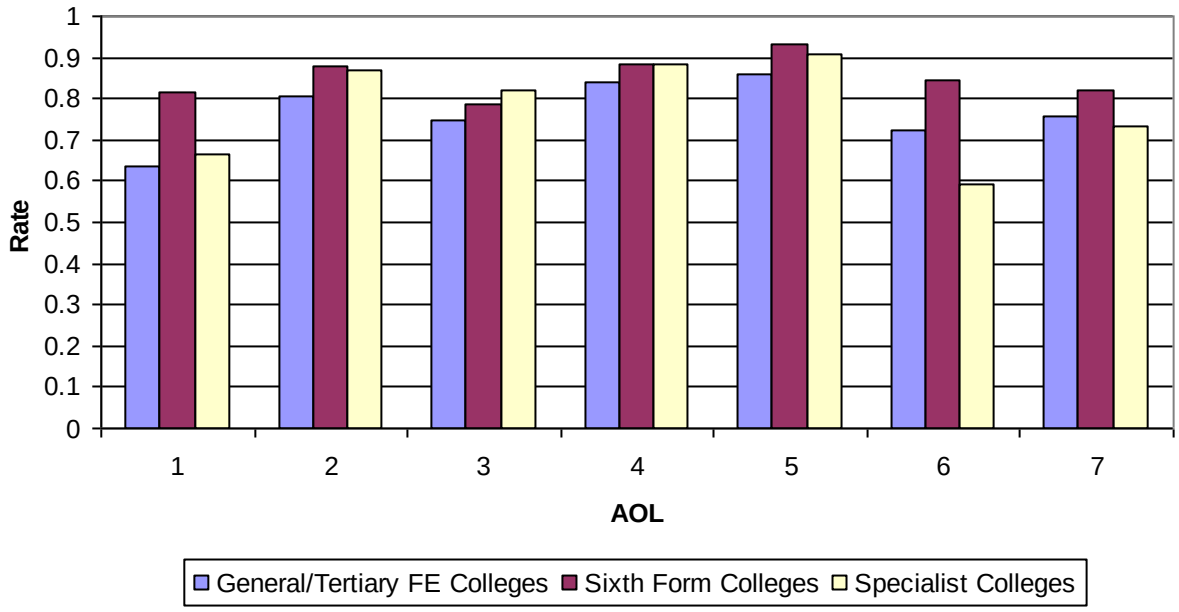
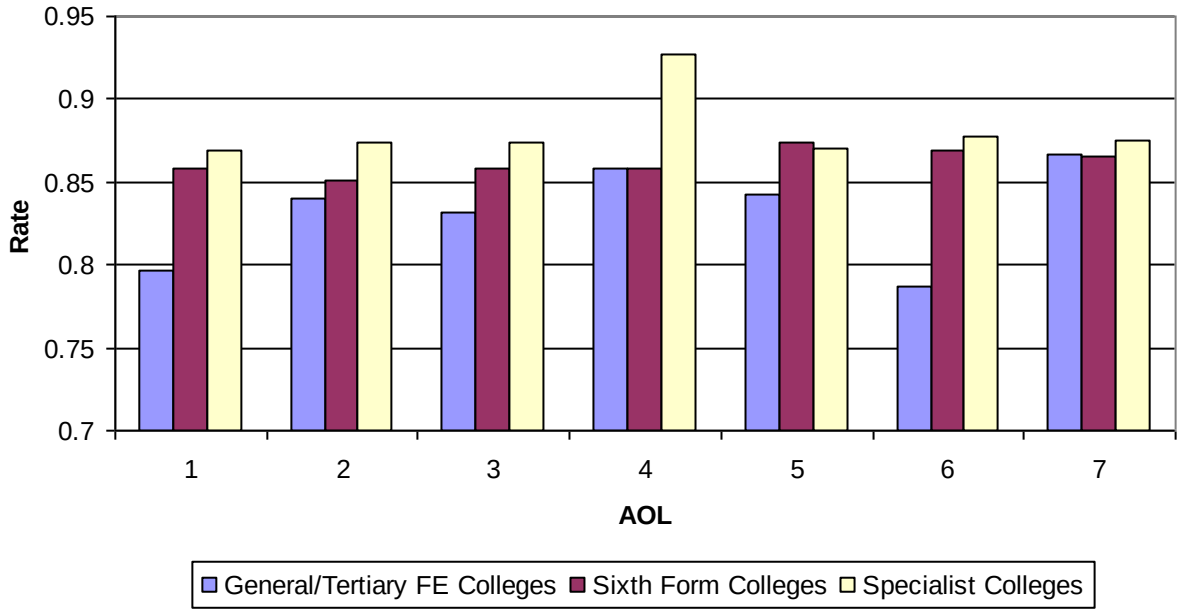


Figure 1b: Retention rate by broad AOL and type of FE institution



Note: See appendix for definition of AOL

Table 1a Achievement and retention rates by AOL and by broad subject area

	ALL QUALIFICATIONS				
	Achievement rate		Retention rate		n
Area of learning	mean	sd	mean	sd	
Science	0.71	0.20	0.79	0.11	1023
Science and mathematics	0.71	0.20	0.79	0.11	1023
Vocational trades	0.81	0.19	0.84	0.12	1973
Land based provision	0.81	0.22	0.85	0.15	609
Construction,	0.80	0.18	0.83	0.13	568
Engineering, technology & manufacturing	0.82	0.15	0.84	0.10	796
Business & related	0.75	0.17	0.84	0.09	2152
Business administration, management & professional	0.78	0.14	0.85	0.08	1066
Information & communication technology	0.72	0.18	0.84	0.10	1086
Personal services	0.84	0.17	0.86	0.11	3384
Retailing, customer service & transportation	0.82	0.21	0.85	0.13	709
Hospitality, sports, leisure & travel	0.85	0.16	0.89	0.09	958
Hairdressing & beauty therapy	0.84	0.18	0.82	0.11	723
Health, social care & public services	0.86	0.15	0.88	0.09	994
Arts	0.84	0.18	0.85	0.09	1016
Visual & performing arts & media	0.84	0.18	0.85	0.09	1016
Humanities	0.75	0.19	0.79	0.13	1968
Humanities	0.79	0.16	0.78	0.14	942
English, languages & communication	0.71	0.21	0.80	0.11	1026
Foundation	0.75	0.21	0.87	0.09	1026
Foundation programmes	0.76	0.21	0.87	0.09	1026
All AOLs	0.79	0.19	0.84	0.11	12542

Table 1b Achievement and retention rates by AOL and by broad subject area – DEA and Tobit samples

	DEA Sample					Tobit Sample				
	Achievement rate		Retention rate		n	Achievement rate		Retention rate		n
Area of learning	mean	sd	mean	sd		mean	sd	mean	sd	
Science	0.69	0.18	0.82	0.08	703	0.68	0.17	0.82	0.07	504
Science and mathematics	0.69	0.18	0.82	0.08	703	0.68	0.17	0.82	0.07	504
Vocational trades	0.82	0.14	0.84	0.08	1226	0.80	0.12	0.84	0.06	493
Land based provision	0.84	0.16	0.85	0.10	281	0.81	0.18	0.85	0.07	46
Construction,	0.81	0.14	0.83	0.08	373	0.81	0.12	0.83	0.07	167
Engineering, technology & manufacturing	0.81	0.12	0.85	0.07	572	0.79	0.11	0.84	0.06	280
Business & related	0.76	0.14	0.84	0.07	1366	0.75	0.13	0.84	0.07	1049
Business administration, management & professional	0.80	0.10	0.85	0.06	710	0.79	0.09	0.85	0.06	514
Information & communication technology	0.71	0.15	0.83	0.08	656	0.71	0.14	0.82	0.08	535
Personal services	0.85	0.14	0.86	0.08	2222	0.85	0.12	0.87	0.07	1277
Retailing, customer service & transportation	0.83	0.17	0.86	0.11	377	0.83	0.15	0.86	0.10	132
Hospitality, sports, leisure & travel	0.85	0.13	0.88	0.07	683	0.84	0.11	0.88	0.06	445
Hairdressing & beauty therapy	0.85	0.14	0.82	0.09	493	0.84	0.13	0.82	0.07	234
Health, social care & public services	0.86	0.12	0.87	0.06	669	0.85	0.11	0.87	0.05	466
Arts	0.88	0.11	0.85	0.06	614	0.87	0.10	0.85	0.06	372
Visual & performing arts & media	0.88	0.11	0.85	0.06	614	0.87	0.10	0.85	0.06	372
Humanities	0.75	0.17	0.81	0.08	1173	0.74	0.17	0.81	0.07	803
Humanities	0.80	0.12	0.81	0.08	586	0.80	0.12	0.81	0.08	381
English, languages & communication	0.70	0.19	0.81	0.07	587	0.70	0.19	0.81	0.07	422
Foundation	0.77	0.16	0.87	0.07	538	0.76	0.15	0.87	0.06	414
Foundation programmes	0.77	0.16	0.87	0.07	538	0.76	0.15	0.87	0.06	414
All AOLs	0.80	0.16	0.84	0.08	7842	0.78	0.15	0.84	0.07	4912

Note: The DEA sample differs to the Tobit sample because of the absence of teacher characteristic variables.

Table 2a: Mean values of the variables included in the DEA analysis

		Science	Vocational trades			Business & Related		Personal services				Arts	Humanities		Found-ation
Variable	AOL[1] / All	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of students	1328	1102	511	837	703	1434	2812	381	1302	595	2317	1105	856	1433	1895
Number of teachers	32	29	15	24	24	44	22	23	30	30	50	40	26	28	43
No. of students retained	963	867	350	611	520	1124	2124	266	838	455	1257	895	675	1118	1469
No. of qualifications achieved	835	660	315	448	388	891	1484	209	763	443	1085	1020	787	829	1632
DEA (n)	7842	703	281	373	572	710	656	377	683	493	669	614	586	587	538

Note:

1. AOL is defined in the Appendix

Table 2b: Mean values of the variables included in the statistical analysis

Variable	AOL[1] / All	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Female	56.42	53.08	62.87	6.37	12.50	61.88	55.98	57.30	59.74	87.91	70.06	62.93	62.41	57.62	53.87
Pakistani/Bangladeshi	4.55	5.81	1.56	1.95	3.56	4.77	4.30	4.59	2.90	3.51	3.32	4.23	5.78	5.22	7.32
Black	6.72	7.63	4.80	4.59	6.64	6.42	5.81	7.21	6.06	5.36	7.03	7.47	7.92	6.25	7.97
Indian	3.46	4.04	1.89	1.89	3.27	4.10	3.77	5.25	2.55	3.71	2.17	3.39	4.34	3.52	3.43
Other	6.56	6.93	4.98	3.86	6.41	5.71	5.49	5.11	5.35	6.52	4.23	6.41	6.71	7.54	13.27
Mature	59.30	31.08	82.85	74.46	65.36	68.63	63.33	83.65	66.29	71.18	75.48	50.82	40.40	40.29	68.23
Immigrant	1.65	1.32	1.31	0.58	1.87	1.36	0.85	1.87	0.90	1.34	0.69	0.97	1.56	3.22	4.78
Learning disability	13.32	14.00	19.06	11.68	10.69	9.29	12.59	9.26	12.16	12.12	11.45	14.32	12.18	11.51	27.51
Non-widening participation	64.65	64.23	71.51	67.42	67.49	69.98	69.35	64.20	68.83	64.15	67.39	67.58	66.49	67.25	34.50
Unemployment rate	5.22	5.21	5.46	5.49	5.43	5.21	5.08	5.46	5.15	5.40	5.18	5.31	5.22	5.17	5.07
PCNOQL	15.49	15.46	15.28	15.91	15.61	15.43	15.36	16.39	15.50	15.73	15.56	15.50	15.45	15.27	15.28
AOL size	1716	1242	943	1239	1038	1698	3102	606	1607	785	2861	1271	950	1585	2206
Provider size	13875	12145	13742	19579	16421	12736	12520	18324	14063	16979	14012	13547	12647	12697	14238
Age of teachers	43.67	45.77	41.50	46.76	47.73	44.54	42.95	43.88	41.51	40.22	44.15	40.72	43.38	43.15	44.30
Ratio of Pakistani/Bangladeshi teachers to students	0.46	0.43	0.28	0.30	0.70	0.40	0.57	0.12	0.32	0.34	0.66	0.19	0.54	0.76	0.34
Ratio of Black teachers to students	0.83	1.03	0.01	0.45	0.64	0.80	0.87	0.80	0.82	1.24	1.33	0.67	0.67	0.51	0.74
Ratio of Indian teachers to students	1.26	1.76	0.73	0.71	1.25	1.27	1.34	0.72	1.31	0.87	2.01	0.31	1.07	1.10	1.55
Ratio of Other teachers to students	0.67	0.63	0.31	0.84	0.99	0.59	0.59	1.12	0.57	0.75	0.77	0.48	0.57	1.10	0.24
Permanent and fixed term staff	85.47	90.20	84.27	84.39	88.13	87.56	85.18	84.02	84.53	77.80	82.99	84.13	89.94	84.05	83.45
Ratio of students to staff	114.96	77.53	70.16	66.53	47.36	44.69	320.41	182.59	80.70	73.43	81.98	60.50	76.31	172.10	154.66
Teacher experience in years	5.26	7.74	5.29	5.80	7.40	5.91	4.06	4.37	5.01	4.16	4.09	4.78	6.53	4.37	3.94
Tobit (n)[2]	4912	504	46	167	280	514	535	132	445	234	466	372	381	422	414

Note:

1. AOL is defined in the Appendix
2. n is the sample size when staff variables are included in the Tobit analysis. The sample size when staff variables are excluded is higher, and hence there is a discrepancy between student numbers in Tables 2a and 2b.

Table 3: Summary of overall (CRS) technical efficiencies by AOL and by broad subject area

AOL	n	Lower quartile	Median	Upper quartile	Mean	sd
Science	703	76.90	82.70	88.16	82.08	9.34
Science and mathematics	703	76.90	82.70	88.16	82.08	9.34
Vocational trades	1226	73.81	80.70	86.97	79.03	13.00
Land based provision	281	73.38	79.98	88.13	79.49	13.78
Construction,	373	71.06	78.90	85.70	77.26	13.40
Engineering, technology & manufacturing	572	75.15	81.77	87.13	79.95	12.22
Business & related	1366	76.62	82.31	87.56	81.21	10.37
Business administration, management & professional	710	78.80	83.06	87.69	82.21	9.84
Information & communication technology	656	74.10	81.11	87.43	80.12	10.82
Personal services	2222	66.67	78.30	86.22	74.92	16.78
Retailing, customer service & transportation	377	68.31	80.56	90.22	77.08	18.56
Hospitality, sports, leisure & travel	683	62.27	76.96	87.99	73.72	17.86
Hairdressing & beauty therapy	493	73.68	78.85	83.81	78.26	10.82
Health, social care & public services	669	63.65	76.64	84.86	72.47	17.66
Arts	614	81.68	86.05	90.43	85.76	7.23
Visual & performing arts & media	614	81.68	86.05	90.43	85.76	7.23
Humanities	1173	75.00	80.99	87.83	81.05	9.91
Humanities	586	73.26	80.21	88.04	80.03	10.90
English, languages & communication	587	76.53	81.76	87.66	82.08	8.71
Foundation	538	74.18	81.52	87.66	79.71	12.57
Foundation programmes	538	74.18	81.52	87.66	79.71	12.57
All AOLs	7842	74.04	81.31	87.67	79.39	13.14

Table 4 Mean overall (CRS) technical efficiencies by broad subject area and type of FE provider[1]

Subject (AOL)	General\Tertiary colleges	Sixth Form colleges	Specialist colleges	ALL
Science	80.33	86.59	83.01	82.08
Vocational trades	79.01	87.03	66.93	79.03
Business & related	79.78	85.97	82.15	81.21
Personal services	73.21	83.66	57.00	74.92
Arts	84.35	89.95	85.02	85.76
Humanities	78.32	88.46	89.29	81.05
Foundation	79.51	81.59	84.21	79.71
All AOLs	77.85	86.14	75.12	79.39

Note: 1. These figures are shown only by broad subject group as numbers are small in some AOLs and types of FE college. In addition, only three types of provider are shown as the numbers in the fourth category (External and specialist institutions) are consistently small (n ranges from 2 in 'Vocational trades' to 22 in 'Personal services').

Table 5 The determinants of overall (CRS) technical efficiency: Pooled tobit models

	Model 1		Model 2	
Variables:	Coefficient	t-ratio	coefficient	t-ratio
Student composition (percentages)				
Female	0.109	11.96**	0.184	13.62**
Pakistani/Bangladeshi	0.034	1.49	0.031	1.34
Black	0.051	2.43**	0.038	1.53
Indian	0.124	4.64**	0.127	4.83**
Other	0.016	0.86	0.069	1.91*
Mature (aged 19 or more)	-0.095	-12.55**	-0.106	-10.45**
Immigrant	0.067	1.69*	0.036	0.85
Learning disability	0.013	1.51	0.003	0.28
Non-widening participation	0.080	8.02**	0.080	6.55**
Environmental				
Local unemployment rate	0.304	2.17**	0.326	2.07**
% of local population with no qualifications	0.040	0.78	0.103	1.75*
Subject & Provider				
AOL size (no. of students)	-0.001	-3.31**	-0.000	-1.27
AOL size^2	$-1.68*10^{-8}$	-0.83	$-6.20*10^{-8}$	-2.85**
Provider size (no. of students)	0.000	2.83**	-0.000	-0.22
Provider size^2	$-2.88*10^{-9}$	-2.08**	$2.95*10^{-9}$	1.58
Sixth Form colleges (Dumtyp2)	4.287	7.20**	3.506	4.67**
Specialist colleges (dumtyp3)	-3.398	-4.03**	-5.832	-3.53**
Year 2003	1.217	4.25**	1.767	5.27**
Subject area 2 (Vocational trades)	3.790	5.21**	8.487	8.49**
Subject area 3 (Business and related)	2.438	3.86**	1.291	1.83*
Subject area 4 (Personal services)	-5.204	-8.71**	-6.285	-8.87**
Subject area 5 (Arts)	3.925	5.60**	3.579	4.37**
Subject area 6 (Humanities)	-1.136	-1.90*	-1.923	-2.92**
Subject area 7 (Foundation)	3.687	4.55**	3.486	3.84**
Teaching-related				
Average age of teachers			-0.883	-2.49**
Average age of teachers squared			0.011	2.77**
Ratio Pakistani or Bangladeshi teachers to students			0.059	1.06
Ratio Black teachers to students			-0.024	-0.66
Ratio Indian teachers to students			-0.016	-0.78
Ratio Other teachers to students			0.172	2.41**
% Permanent and fixed term staff			0.016	2.41**
Ratio of students to teachers			0.010	9.66**
Ratio of students to teachers squared			$-7.04*10^{-7}$	-2.38**
Mean number of years with provider (teaching staff)			0.002	0.02
Mean number of years with provider (teaching staff) squared			-0.003	-0.78
Constant	68.496	41.31**	78.932	9.87**
Log Likelihood	-28762.836		-18445.508	
Chi-square (df)	1455.54	(24)	1405.48	(35)
No. of observations	7512		4912	

** = significant at the 5% significance level; * = significant at the 10% significance level.

Table 6: The determinants of subject-level technical efficiency (CRS)

	Science		Vocational trades		Business & related		Personal services		Arts		Humanities		Foundation	
	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio
Female	0.099	1.86*	0.065	2.04**	0.235	5.82**	0.219	8.15**	0.041	0.87	0.113	2.74**	0.185	2.54**
Pakistani/Bangladeshi	-0.013	-0.29	0.055	0.45	0.022	0.54	0.022	0.28	0.080	1.59	0.035	0.98	0.126	2.34**
Black	-0.023	-0.52	0.053	0.59	0.089	1.91*	0.165	2.39**	0.125	2.21**	-0.061	-1.48	0.020	0.23
Indian	0.104	2.15**	0.152	1.32	0.175	4.58**	0.155	1.76*	0.164	2.89**	0.041	1.03	0.067	0.74
Other	0.061	0.87	0.110	0.94	0.076	0.99	0.056	0.47	-0.143	-1.50	0.147	2.47**	-0.056	-0.70
Mature	-0.050	-1.99**	-0.115	-2.86**	-0.161	-7.51**	-0.111	-3.73**	-0.039	-1.58	-0.151	-9.38**	-0.083	-2.13**
Immigrant	0.112	0.82	-0.232	-1.60	-0.113	-0.89	-0.071	-0.46	0.171	1.03	0.134	2.22**	0.043	0.62
Learning disability	-0.034	-1.55	0.022	0.70	-0.031	-1.58	0.007	0.22	-0.014	-0.54	0.013	0.70	0.057	1.77*
Non-widening participation	0.066	2.81**	0.009	0.18	0.093	4.30**	0.148	4.17**	0.096	3.64**	0.077	3.82**	0.000	-0.01
Unemployment rate	0.650	1.96**	-0.518	-1.14	-0.148	-0.54	0.469	1.08	0.286	0.88	0.696	2.64**	0.292	0.54
% of local pop with no quals	0.040	0.32	0.090	0.53	0.195	1.93*	0.312	1.87*	0.134	1.07	0.056	0.57	-0.159	-0.81
AOL size	0.001	0.73	-0.003	-2.07**	-0.001	-2.94**	-0.001	-2.19**	0.004	2.47**	0.003	2.90**	-0.002	-1.50
AOL size2	$8.1*10^{-8}$	0.15	$5.5*10^{-7}$	2.26**	$6.6*10^{-8}$	2.19**	$-9.9*10^{-8}$	-1.96**	$-5.5*10^{-7}$	-1.59	$-4.0*10^{-7}$	-1.98**	$1.8*10^{-7}$	1.59
Provider size	-0.0004	-1.98**	0.0004	1.70*	0.0002	1.08	-0.00008	-0.36	-0.0002	-1.32	-0.0002	-1.72*	-0.0003	-1.10
Provider size2	$8.8*10^{-9}$	2.12**	$-6.4*10^{-9}$	-1.30	$2.1*10^{-11}$	0.01	$5.7*10^{-9}$	1.12	$5.9*10^{-9}$	1.62	$4.6*10^{-9}$	1.47	$1.1*10^{-8}$	1.70*
Sixth Form	4.262	2.87**	0.880	0.22	-0.630	-0.48	4.814	2.23**	4.629	2.84**	2.477	2.10**	0.091	0.04
Specialist	5.292	1.39	-1.773	-0.51	-2.608	-0.66	-15.067	-3.35**	-2.063	-0.58	-2.801	-0.73	1.343	0.26
Year 2003	2.268	3.29**	3.062	3.06**	1.131	2.02**	4.288	4.67**	-0.803	-1.14	1.142	2.04**	-2.195	-1.87*
Average age of teachers	0.154	0.13	-1.737	-2.08**	-1.165	-1.55	-0.340	-0.34	0.027	0.02	-1.043	-1.71*	4.083	2.29**
Average age of teachers squared	-0.000	-0.01	0.020	2.31**	0.013	1.48	0.006	0.55	-0.001	-0.06	0.012	1.75*	-0.046	-2.25**
Ratio Pakistani or Bangladeshi teachers to students	-0.059	-0.50	0.203	1.08	-0.032	-0.44	0.403	2.40**	0.285	1.07	0.039	0.54	-0.333	-0.88
Ratio Black teachers to students	0.017	0.25	-0.174	-0.44	-0.115	-1.27	-0.099	-1.37	-0.084	-0.63	0.060	1.02	0.137	0.96
Ratio Indian teachers to students	0.028	0.47	-0.041	-0.40	0.121	2.85**	0.013	0.29	-0.022	-0.09	-0.012	-0.39	-0.143	-2.97**
Ratio Other teachers to students	0.082	0.37	0.172	1.48	0.161	1.09	0.269	1.35	-0.258	-0.94	-0.177	-1.61	0.312	0.49
% Permanent and fixed term staff	0.014	0.72	0.029	1.29	0.006	0.51	0.017	0.98	-0.010	-0.73	0.014	1.32	0.019	0.94
Ratio of students to teachers	0.029	5.05**	0.017	0.82	0.000	0.17	0.032	6.67**	0.011	0.96	0.012	4.97**	0.004	0.77
Ratio of students to teachers squared	-0.000	-3.00**	0.000	1.14	0.000	1.67*	-0.000	-1.65*	0.000	1.17	-0.000	-1.48	0.000	0.99
Mean number of years with provider (teaching staff)	-0.066	-0.35	0.032	0.09	0.121	0.71	-0.236	-0.62	0.056	0.21	-0.042	-0.29	-0.025	-0.07
Mean number of years with provider (teaching staff) squared	-0.001	-0.17	-0.007	-0.35	-0.003	-0.57	0.010	0.46	-0.011	-1.03	0.000	0.00	-0.009	-0.89
Constant	59.077	2.20**	115.236	5.30**	92.317	5.68**	46.699	2.10**	71.581	2.81**	87.409	6.36**	-11.991	-0.31

Log Likelihood	-1688.07		-1795.81		-3672.68		-5159.31		-1182.20		-2678.47		-1544.40	
Chi-square	157.27	(29)	115.36	(29)	270.50	(29)	365.88	(29)	140.05	(29)	476.20	(29)	83.76	(29)
Sample size	504		493		1049		1277		372		803		414	

** = significant at the 5% significance level; * = significant at the 10% significance level.

APPENDIX: **Definitions of AOLs and broad subject areas**

AOL	Broad subject	Definition
	1	*Science*
1		Science and mathematics
	2	*Vocational trades*
2		Land based provision
3		Construction,
4		Engineering, technology & manufacturing
	3	*Business & related*
5		Business administration, management & professional
6		Information & communication technology
	4	*Personal services*
7		Retailing, customer service & transportation
8		Hospitality, sports, leisure & travel
9		Hairdressing & beauty therapy
10		Health, social care & public services
	5	*Arts*
11		Visual & performing arts & media
	6	*Humanities*
12		Humanities
13		English, languages & communication
	7	*Foundation*
14		Foundation programmes