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MEASUREMENT AND DETERMINANTS OF EFFICIENCY AND PRODUCTIVITY IN THE FURTHER EDUCATION SECTOR IN ENGLAND

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ABSTRACT

This study uses data for nearly 200 further education providers in England to investigate the level of efficiency and change in productivity over the period 1999–2003. Using data envelopment analysis we find that the mean provider efficiency varies between 83 and 90 percent over the period. Productivity change over the period was around 12 percent, and this comprised 8 percent technology change and 4 percent technical efficiency change. A multivariate analysis is therefore performed, which shows that, in general, student-related variables such as gender, ethnic and age mix are more important than staff-related variables in determining efficiency levels. The local unemployment rate also has an effect on provider efficiency. The policy implications of the results are that further education providers should implement strategies to improve the completion and achievement rates of white males, and should also offer increased administrative support to teachers.

Keywords: data envelopment analysis, efficiency, further education, productivity change
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I. INTRODUCTION

In recent years, performance in English education has been the subject of considerable scrutiny. Indeed, there is a plethora of studies measuring the performance of primary, secondary and tertiary education (see Johnes, 2004), but there is no study of the performance of the further education (FE) sector in England.[1] This is somewhat surprising since the sector is substantial in terms of both student numbers and government funding. For instance, the sector attracted 6 million students in 2004–05, having risen from a base of 4 million students 7 years previously, accompanied by a 48 percent increase between 1997 and 2006 in funding measured in real terms (DfES, 2006). This expansion of the FE sector is likely to continue: the age at which pupils must be in education or training has risen for pupils entering secondary education in September 2008 to age 17, and, by 2013, this will have risen to age 18. In addition, the Government aims to have half of the relevant age group continuing on to higher education. Furthermore, the FE sector, as a provider of the academic and vocational skills required by the labour market, is key to achieving the Government's education and training targets. The FE sector also plays a crucial role in reducing social and ethnic disparities, because the institutions within this sector cater for a wide range of socio-economic groups and a disproportionate share of Britain's ethnic minorities.

The importance of the FE sector is therefore not in dispute. There is also evidence that the performance of the sector has improved in recent years. For example, the Foster Report notes that success rates in exams have risen from 59 percent in 2000–01 to 72 percent in 2003–04; nevertheless, the view of the Report is that the FE sector is not realizing its full potential. The proportion of young people staying on in education and training post-16, for example, is extremely low by international standards: the UK ranks 24th out of 29 developed nations (DfES, 2006). In addition, 200,000 16–18-year-olds in the UK are unemployed (DfES, 2006) and there are low levels of literacy amongst the workforce (Foster Report, 2005). Nevertheless, the improvement in success rates for the sector as a whole masks a wide variation both between colleges and between subject areas. In addition, recruitment and retention problems suggest that staff morale is low in some localities, and there are problems with resource allocation (Foster Report, 2005, p. 16). In consequence, it is recommended that all providers in the FE sector need to be brought up to the level of the 'best' (Foster Report, 2005, p. 53), and clear, accessible performance indicators are needed in order to allow comparisons and to

[1] The FE sector sits between compulsory schooling and entrance to university. Therefore, the sector typically provides academic and vocational education for 16–19-year-olds.

make improvements (DfES, 2006, p. 58).[2] There is no doubt, therefore, that technical efficiency and productivity could be improved amongst providers in the FE sector.

However, the precise level of efficiency in the FE sector cannot easily be established. This situation is made worse by the complexity of the FE sector itself in so far as it comprises different types of providers that have different objectives and meet the needs of different groups of students. General FE/tertiary colleges provide a wide range of vocational courses at foundation and intermediate levels, as well as academic courses such as A levels, which are the usual stepping stone into higher education. Sixth forms linked to secondary schools and sixth form colleges, on the other hand, offer a narrower range of courses and tend to focus on academic provision. Specialist colleges exist to serve the needs of drama, music, agriculture and horticulture students, and lastly the external and specialist colleges provide mainly further education for adults.

The purpose of this paper is to perform the first systematic study of the variation in the efficiency among FE providers taking explicit account of the complexity of the sector. The data that form the basis of the study have been obtained from the Learning and Skills Council (LSC), and refer to the population of providers in the sector for the period 1999–2003. However, data limitations mean that a complete set of data on students and staff for all years of the analysis can be derived for 188 providers.[3] The time series nature of the data set allows a detailed analysis of how efficiency and associated productivity in the FE sector have changed over time. Our analysis is undertaken in two parts. First, the efficiency levels and productivity indices of a sample of 188 FE providers are derived using a distance function approach. Second, we investigate what factors affect the level and change in efficiency using a random effects panel approach to control for unobserved heterogeneity between providers. Examination of the underlying determinants of data envelopment analysis (DEA) efficiency scores has become commonplace in the literature; however, there are only a few previous studies that look at the underlying determinants of the Malmquist productivity change index, or its components, and none in the area of education of which we are aware. This paper therefore adds to the existing literature by conducting such an investigation. In sum, our study offers a baseline view of the sector, and a basis for the implementation of initiatives to raise the performance of poor providers.

[2] The ‘best’ colleges are identified as those that offer a range of courses to meet the diverse needs of the student body, try to raise the aspirations of students, equip students with the skills needed by business, offer bridging courses in conjunction with secondary schools, and have a ‘qualified, professional and highly committed workforce’.

[3] Data relating to students and their characteristics can be derived for 516 providers for each of the years of the study. Once variables reflecting teaching numbers and their characteristics are added, the sample falls to 188 providers.

The paper is in five sections. Section II sets out the methodology that will be used to derive the efficiency measures of the FE providers, and the techniques that will be used in the second stage multivariate analysis of the efficiency scores. Section III provides a short background of the English FE sector and describes the data and models used in the analysis. Results are reported in Section IV. Conclusions and recommendations are discussed in Section V.

II. METHODOLOGY

II.1 Efficiency and productivity measurement

The distance function methodology is attractive in the context of performance in the FE sector because it allows for both multiple outputs and multiple inputs, without requiring either knowledge of input or output prices or an assumption of profit maximization or cost minimization on the part of the FE colleges (Coelli and Perelman, 1999). A further advantage when a panel of data is available is that changes in productivity growth over the period can also be derived.

Let us assume time periods $t = 1, \dots, T$, and define the production technology of a decision-making unit (DMU), in this case an FE provider, in time t, as P^t, which represents the transformation of the inputs $x^t \in \Re^m_+$ into the outputs $y^t \in \Re^s_+$. Hence

$$P^t = \{(x^t, y^t) : x^t \text{ can produce } y^t\}$$

The output distance function measuring technical efficiency at time t (Shepherd, 1970; Färe, 1988; Färe *et al.*, 1994) is defined as

$$D_O^t(x^t, y^t) = \min_\theta\{\theta : (x^t, y^t/\theta) \in P^t\} = (\max\{\theta : (x^t, \theta y^t)\} \in P^t)^{-1} \quad (1)$$

$D_O^t(x^t, y^t) \leq 1$ for values $(x^t,\ y^t) \in P^t$ and $D_O^t(x^t, y^t) = 1$ if and only if $(x^t,\ y^t)$ is on the boundary. $D_O^{t+1}(x^{t+1}, y^{t+1})$ is defined similarly and can be used to measure technical efficiency in time period $t + 1$.

The Malmquist productivity change index is defined as (Caves *et al.*, 1982)

$$M_O(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)}\right)\left(\frac{D_O^{t+1}(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^t, y^t)}\right)\right]^{1/2} \quad (2)$$

where $D_O^t(x^{t+1}, y^{t+1})$ and $D_O^{t+1}(x^t, y^t)$ are mixed period distance functions defined as

$$D_O^t(x^{t+1}, y^{t+1}) = \min\{\theta : x^{t+1}, y^{t+1}/\theta) \in P^t\}$$
$$D_O^{t+1}(x^t, y^t) = \min\{\theta : x^t, y^t/\theta) \in P^{t+1}\} \quad (3)$$

If the Malmquist productivity change index exceeds unity there has been an improvement in overall productivity between t and $t+1$. Values less than 1 imply the converse. In addition, the index can be broken into two components (Färe *et al.*, 1989; Färe *et al.*, 1992):

$$M_O(x^{t+1}, y^{t+1}, x^t, y^t) = ET = \left(\frac{D_O^{t+1}(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)}\right)\left[\left(\frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_O^t(x^t, y^t)}{D_O^{t+1}(x^t, y^t)}\right)\right]^{1/2} \quad (4)$$

The component E measures the change in *technical efficiency*, and shows whether the DMUs are getting closer to their production frontiers over time, implying that FE providers are using existing resources more efficiently, holding technology constant. Examples of how this might occur include increases in managerial or teaching efficiency, such as teaching students in larger groups. The component T measures change in *technology* over the period, and indicates whether the production frontier is shifting over time. Examples may include different ways of teaching, such as e-learning. Values of either of these components of greater (less) than unity suggest improvement (deterioration).

Distance functions can be estimated using parametric or non-parametric techniques. The former can create specification errors by virtue of the assumptions the researcher makes regarding particular functional forms for the production function, and because of a specific statistical distribution of the efficiencies. We therefore prefer to take a non-parametric approach, which involves the solution of the following (output-oriented) linear programmes for DMU k (from a set of DMUs $j = 1, \ldots, n$):

$$\left[D_O^t(x^t y^t)\right]^{-1} = \max \phi_k \quad (5)$$

subject to

$$\phi_k y_{rk}^t - \sum_{j=1}^{n} \lambda_j y_{rj}^t \leq 0 \qquad r = 1, \ldots, s$$

$$x_{ik}^{t} - \sum_{j=1}^{n} \lambda_j x_{ij}^{t} \geq 0 \qquad i = 1, \ldots, m$$

$$\lambda_j \geq 0 \;\; \forall j = 1, \ldots, n$$

$$\left[D_O^{t}(x^{t+1}, y^{t+1})\right]^{-1} = \max \phi_k \tag{6}$$

subject to

$$\phi_k y_{rk}^{t+1} - \sum_{j=1}^{n} \lambda_j y_{rj}^{t} \leq 0 \qquad r = 1, \ldots, s$$

$$x_{ik}^{t+1} - \sum_{j=1}^{n} \lambda_j x_{ij}^{t} \geq 0 \qquad i = 1, \ldots, m$$

$$\lambda_j \geq 0 \;\; \forall j = 1, \ldots, n$$

$$\left[D_O^{t+1}(x^{t+1} y^{t+1})\right]^{-1} = \max \phi_k \tag{7}$$

subject to

$$\phi_k y_{rk}^{t+1} - \sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \leq 0 \qquad r = 1, \ldots, s$$

$$x_{ik}^{t+1} - \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \geq 0 \qquad i = 1, \ldots, m$$

$$\lambda_j \geq 0 \;\; \forall j = 1, \ldots, n$$

$$\left[D_O^{t+1}(x^{t}, y^{t})\right]^{-1} = \max \phi_k \tag{8}$$

subject to

$$\phi_k y_{rk}^{t} - \sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \leq 0 \qquad r = 1, \ldots, s$$

$$x_{ik}^{t} - \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \geq 0 \qquad i = 1, \ldots, m$$

$$\lambda_j \geq 0 \;\; \forall j = 1, \ldots, n$$

where subscript i represents the ith input ($i = 1, \ldots, m$), r represents the rth output ($r = 1, \ldots, s$), λ_j is an $n \times 1$ vector of constants, and ϕ_k is a scalar. It should be noted that $1 \leq \phi_k < \infty$ in Equations (5) and (7) since $1/\phi_k$ is the output-oriented DEA measure of technical efficiency (under constant returns to scale) in period t (if calculated using Equation (5)) or in period $t + 1$ (if calculated using Equation (7)). Note, however, that ϕ_k need not exceed 1 in Equations (6) and (8) since points are compared to production technologies from different time periods (Coelli *et al.*, 1998).

In sum, DEA provides non-parametric estimates of the distance functions required to calculate technical efficiency and productivity change indices. While the deterministic nature of the technique does not allow for stochastic errors (and this may well be a serious drawback in the context of education), this is balanced by a number of advantages. DEA easily handles multiple outputs and multiple inputs; it does not require knowledge of input or output prices; and the efficiency and productivity measures provided by DEA do not incorporate specification errors.

II.2 Multivariate analysis of the factors affecting efficiency and productivity

One well-known disadvantage of DEA 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 *et al.*, 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; Bradley *et al.*, 2001; Grosskopf and Moutray, 2001; Ramanathan, 2001; Bratti, 2002). 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. In practice, it is often the environmental variables (i.e., those variables over which managers have little or no control) that are reserved to the second stage. The precise variables included in the DEA and statistical models are discussed in Section III.

As noted in Section II.1, the DEA technique produces efficiency scores, denoted by z_{kt}, the efficiency score of DMU k in time period t (calculated as $100 \times 1/\phi_k$ from Equation (5)), and by z_{kt+1}, the efficiency score of DMU k in time period $t + 1$ (calculated as $100 \times 1/\phi_k$ from Equation (7)). All efficiency scores (z_{jt} for DMUs $j = 1, \ldots, n$) are bounded by 0 and 100 (although the left hand boundary cannot be observed). The appropriate approach to modelling a censored dependent variable is to use a Tobit model. Also, the panel nature of the data allows us to control for unobserved and unobservable determinants of efficiency, such as college ethos or the management's ability. Thus the possible determinants of the efficiencies of FE providers are investigated using a random effects Tobit model.[4] The model is specified in terms of the latent variable z^*_{jt} as

$$z^*_{jt} = w_{jt}\beta + v_j + \varepsilon_{jt} \tag{9}$$

where subscript j represents the jth DMU ($j = 1, \ldots n$); subscript t represents time period t ($t = 1, \ldots, T$); $v_j \sim \mathrm{N}(0, \sigma^2_v)$ and represents the random effects; $\varepsilon_{jt} \sim \mathrm{N}(0, \sigma^2_\varepsilon)$ and is independent of v_j; and w_{jt} is a set of environmental and uncontrollable variables. The observed efficiency of DMU j at time t is given by z_{jt} and is related to the latent variable z^*_{jt} as follows:

$$\begin{aligned} z_{jt} &= L_{1jt} && \text{if } z^*_{jt} \leq L_{1jt} \\ z_{jt} &= z^*_{jt} && \text{if } L_{1jt} < z^*_{jt} < L_{2jt} \\ z_{jt} &= L_{2jt} && \text{if } z^*_{jt} \geq L_{2jt} \end{aligned} \tag{10}$$

where L_{1jt} and L_{2jt} are the lower and upper bounds of the data. In practice, no observations are at the lower bound and so a right censored random effects Tobit model is estimated.

While examination of the underlying determinants of DEA efficiency scores has become a common extension of the DEA technique, we are not aware of any previous studies that look at the underlying determinants of the Malmquist productivity change index, or its components. Since the value of these productivity measures is not restricted to fall within particular bounds, ordinary least square (OLS) methods are used to investigate how M, E and T within each college can be explained by temporal variations in the composition and size of the student body, and by environmental characteristics.

III. THE FE SECTOR AND THE SAMPLE DATA

III.1 The FE sector

The FE sector in England comprises various types of institutions. General FE/tertiary colleges are the largest group, offer a broad range of vocational and academic subjects at various levels, and are attended by both

[4] A random effects model assumes the unobservable effects are uncorrelated with the observed explanatory variables, and models the individual-specific intercept terms as randomly distributed over all units of observation (FE colleges). A fixed effects model assumes that the unobservable effects are correlated with the observed explanatory variables, but, when the time dimension of the panel is short (as here), most of the variation in the dependent and independent variables is across units, and so the fixed effects approach can introduce problems of multicollinearity and reduce the precision of the estimates. A random effects model is therefore preferred.

young people and adults. Sixth form colleges also form a large group and have traditionally catered for 16–19-year-olds taking advanced level academic courses. More recently, they have broadened both their course offering and their student profile. Specialist colleges concentrate on specific areas of the curriculum, and often have well developed links with employers and industry because of the specialist nature of the subjects taught. Specialist designated and external institutions cater mainly for adults; external institutions also cater to the needs of educationally disadvantaged students.

Most colleges derive the bulk of their income centrally from public sources, which has been distributed by the LSC since it was set up in 2001. Funding is allocated on the basis of a formula that has five components. The first is a national base rate which reflects the length and cost of the provision of various programmes; the second is a weighting for more costly programmes; the third component is a weighting for learners achieving the programme for which they enrolled; the fourth component is an uplift applied for colleges taking learners from specified disadvantaged backgrounds; and the fifth is an additional amount paid to colleges in geographical areas where provision is more costly (e.g., London). On average, 78 percent of FE colleges' income comes from the LSC, while 7 percent comes from fees from employers or individuals (Foster Report, 2005).

In addition to the central nature of their funding, the FE colleges are also subjected to a national system of inspection to ensure standards are maintained. This is in stark contrast to the system faced by community colleges in the USA, for example. Like FE colleges, community colleges offer a wide range of programmes to a widely diverse student body, i.e., in terms of age and ethnic background. But community colleges are driven by the local community in which they are located, providing the skills necessary to encourage local economic development. In addition, attendance at a community college is a recognized and common route into university education. It is these close links with universities that mean that quality and standards in community colleges are high despite their being self rather than centrally regulated.

III.2 DEA and the data

DEA requires a full set of inputs and outputs. For FE providers, the main inputs refer to the quantity and quality of students and the quantity and quality of teachers, while outputs are students' achievements. These are measured by the retention of students (the inverse of dropping out), and the number of aimed-for qualifications that are actually attained by students. We therefore specify the following DEA model:

Inputs

Notwp_{jt}	the number of students in a given year who do not qualify for widening participation uplift factor
Student_{jt}	the total number of students in a given year
Teach_{jt}	the total number of teachers in a given year
Qualteach_{jt}	the number of teaching staff in a given year who have qualified teaching status:

Outputs

Retnum_{jt}	the number of students in a given year who have not withdrawn during the year (i.e., they are retained). Note that this variable is measured at student level.
Achieve_{jt}	the number of qualifications aimed for that are actually achieved during a particular year. Note that this variable is measured at the qualification level.
j	college or decision-making unit.
t	year.

Student and staff numbers (Student and Teach) are included to reflect the basic inputs to the FE process. Since these variables purely reflect the quantity of these inputs, the variables Notwp and Qualteach are included to reflect quality. If students come from a poor background then they attract extra government funding because this meets their objective of widening participation in post-compulsory education (see Section III.1). The variable Notwp therefore reflects the socio-economic background of the student, which is known to affect educational attainment and drop out behaviour (Bradley and Lenton, 2007). The quality of the teaching staff is measured by the variable Qualteach, which reflects the number of staff with qualified teaching status.

There are around 600 FE providers in England. A full set of all variables over a period of 5 years is available for a sample of 188 providers. Descriptive statistics are provided in Table 1, from which it is clear that student numbers, on average, have been increasing over the first 4 years of the period, followed by a slight downturn in the final year.[5] The variables Notwp and Retnum exhibit a similar pattern, while the downturn in the final year is not observed for either the teaching variables (Teach and Qualteach) or Achieve. These patterns for the sample data are broadly similar to those observed in the full data set (also reported in Table 1). It should be noted, however, that variables derived from the student data (numbers and attainment variables) have larger means for the sample data than for the population. The fact that

[5] It should be noted that, since Achieve is derived from qualifications data, and each student is likely to take more than one qualification, average student numbers are less than average achievement numbers.

TABLE 1
Descriptive statistics by cohort

	1999		*2000*		*2001*		*2002*		*2003*	
	sample 188	*full*[a] 610	*sample* 188	*full*[a] 609	*sample* 188	*full*[a] 603	*sample* 188	*full*[a] 595	*sample* 188	*full*[a] 553
Variable	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Student	8899	6436	9591	6948	10,289	7704	10,934	8490	10,169	8273
	(7873)	(7880)	(8244)	(8093)	(8853)	(8642)	(9553)	(9651)	(8405)	(9095)
Notwp	6408	4461	6809	4715	7159	5153	7647	5706	6657	5272
	(5712)	(5680)	(5881)	(5758)	(6119)	(6030)	(6554)	(6694)	(5447)	(5978)
Teach	317	313	317	312	318	325	342	340	347	349
	(252)	(240)	(252)	(240)	(247)	(247)	(258)	(267)	(255)	(266)
Qualteach	190	188	190	188	187	186	193	187	199	197
	(171)	(162)	(171)	(163)	(171)	(169)	(167)	(163)	(177)	(171)
Retnum	5703	4097	5879	4222	6093	4440	7877	6180	7253	6019
	(4873)	(4901)	(5052)	(4821)	(5113)	(4818)	(6555)	(7140)	(5564)	(6716)
Achieve	7718	5401	9123	6247	9855	6999	9505	6735	10,670	8109
	(6383)	(6840)	(6409)	(7131)	(6800)	(7677)	(6150)	(6529)	(6951)	(7437)

Notes: [a]The full data are derived from the LSC. It should be noted that the descriptive statistics for the teaching-related variables are based on incomplete records (1999: $n = 285$; 2000: $n = 283$; 2001: $n = 270$; 2002: $n = 370$; 2003: $n = 361$) and hence cannot be considered to be the population values.
See the Appendix for full definition of variables.

TABLE 2
Descriptive statistics by college type

	General FE/ tertiary colleges		Sixth form colleges		Specialist colleges		External and specialist	
n (over 5 years)	*610*	*1293*	*290*	*506*	*40*	*192*	*0*	*974*
Variable	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Student	14,028	13,978	2262	2215	4119	2134		2895
	(8126)	(8108)	(1492)	(1340)	(2110)	(2284)		(6702)
Notwp	9634	9413	1730	1638	3535	1834		1701
	(5722)	(5734)	(1281)	(1162)	(1955)	(2002)		(4664)
Teach	444	438	114	111	121	124		134
	(243)	(246)	(51)	(47)	(49)	(58)		(144)
Qualteach	247	242	92	90	72	65		48
	(189)	(179)	(37)	(36)	(47)	(44)		(42)
Retnum	9132	9225	1746	1723	2259	1261		1756
	(5237)	(5442)	(1086)	(970)	(1344)	(1425)		(4499)
Achieve	11,824	11,809	5080	4756	3144	1635		1845
	(6813)	(6612)	(2659)	(2476)	(1369)	(1767)		(5469)

Notes: The full data are derived from the LSC. It should be noted that the descriptive statistics for the teaching-related variables are based on incomplete records (general FE/tertiary colleges: $n = 1044$; sixth form colleges: $n = 423$; specialist colleges: $n = 85$; external and specialist colleges: $n = 17$) and hence cannot be considered to be the population values.
See the Appendix for full definition of variables.

the sample is biased towards larger providers should be borne in mind when drawing conclusions from this analysis.

Table 2 provides the descriptive statistics by type of provider. This offers insights into why the data are biased towards larger providers, since the sample excludes all external and specialist institutions, which are small, on average, relative to the general FE/tertiary colleges. In fact, external and specialist institutions are substantially different from other types of institutions in terms of their mission and the types of students catered for, and their exclusion from the sample data is therefore desirable. It is also noteworthy that, within the specialist category, the average size for the sample is around 4000 students, whereas the full data set suggests that the average size of this type of institution is just over 2000 students. The fact that, owing to data availability, the smaller specialist institutions are excluded from the sample, and that only eight institutions of this type appear in the sample, suggests that the following results should be interpreted with a degree of caution. An examination of the remaining two categories of FE provider shows that general FE/tertiary colleges are by far the largest type: average student numbers are around 14,000, just over 9000 students are retained on average, and nearly 12,000 qualifications are achieved. This compares with average student numbers of around 2200 in sixth form colleges, which retain 1700 students on average and achieve around 5000 qualifications.

III.3 Explanatory variables in the multivariate analysis of the efficiencies

The socio-demographic composition of the student population can be expected to affect the efficiency of FE colleges. For example, the educational attainment of girls is higher than that for boys in FE (Andrews *et al.*, 2006), and girls are also less likely to drop out (Bradley and Lenton, 2007). In addition, young people from ethnic minority backgrounds tend to stay on in FE to close the so-called ‘qualification gap’ (Bradley and Taylor, 2004) and are less likely to drop out (Bradley and Lenton, 2007).

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 effect on student attainment and 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 in so far as students work harder to secure a job once they complete FE. 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 included to capture two possible effects. First, having qualified parents, which is likely to be highly correlated with socio-economic status, has a positive effect on children’s achievement levels (Naylor and Smith, 2004). Second, it is expected that localities with a high proportion of unqualified adults will have students from low-income families (average income of the local population is not included in the data set). Students from these backgrounds are more likely to drop out and have lower educational attainment (Bradley and Taylor, 2004; Bradley and Lenton, 2007).

It is possible that there may be inter-temporal and inter-institutional differences in efficiency. Some may be a consequence of inter-institutional and inter-temporal variations in the student composition (not accounted for in the production relationship), while some may be genuine differences between types of FE providers and across years of the study. We therefore include controls for year and the type of provider to capture mean differences between years and types of FE provider.

Finally, it is possible to construct an array of variables relating to the staff composition of the FE colleges. Thus the age, ethnic background, mix of staff types, and the ratio of students to staff all may affect the efficiency with which the inputs of FE colleges are converted into outputs.

A final caveat is noted. The data set does not include variables which reflect how well equipped the FE provider is, such as the number of computers or library resources, for example. In so far as these resources are likely to vary little over the time period of the study, then the FE panel regression method controls for such effects.

IV. RESULTS

IV.1 Technical efficiency

The results of applying an output oriented DEA with variable returns to scale (VRS) to the entire data set are summarized in Table 3. After a fall in efficiency for the first 3 years, mean efficiency across the FE sector as a whole shoots up in 2002 and levels off in 2003. Figure 1 shows that this pattern is broadly similar for all types of FE provider, except for specialist colleges. Recall that there are only eight of these types of provider in the sample and they are not typical in terms of size.

The rank correlations between the efficiency scores for pairs of years are highly significant (see Table 4). The lower correlations in the final two rows (excluding the final column) compared to other rows of the table suggest that the efficiencies for 2002 and 2003 are different from those in the earlier 3 years of the study. This suggests that there was a structural break in provider performance from 2002. One possible explanation for this is that the funding and planning system for FE colleges underwent radical changes over this period and this may have affected the data and hence efficiencies for the latter period.

IV.2 Productivity change

Table 5 and Figure 2 show productivity changes (using a base year approach and distance functions calculated on the assumption of constant returns to scale), in the sector as a whole and in the sub-groups of FE providers.[6] Over the entire period, overall productivity has risen by

[6] When there are more than two periods in the sample data, the Malmquist index can be calculated in either of two ways. One approach is to calculate the index for each pair of adjacent years from $t, t+1$ to $T-1, T$ (for $t = 1, \ldots, T$). Alternatively, it can be calculated for each year relative to the same fixed base, i.e., for t relative to s, $t+1$ relative to s, and so on to T relative to s. The value of the Malmquist productivity change index can vary according to the method used, particularly if production frontiers in adjacent periods overlap (Grifell-Tatjé and Lovell, 1996). We therefore repeated the analysis using an adjacent year approach. The results were so similar that only the base year results are reported here. Full results can be found in Bradley *et al.* (2006).

TABLE 3

Descriptive statistics for the VRS efficiencies: all observations and by type of provider

Year	*Minimum*	*Weighted geometric mean*
All FE providers		
1999	52.61	88.82
2000	45.46	85.87
2001	50.70	83.44
2002	38.54	90.23
2003	45.12	89.01
General FE/tertiary		
1999	52.61	89.09
2000	45.46	85.90
2001	51.25	83.48
2002	59.12	90.56
2003	61.48	89.23
Sixth forms and sixth form colleges		
1999	62.00	87.92
2000	63.24	87.14
2001	54.39	86.18
2002	67.94	91.39
2003	51.30	90.01
Specialist colleges		
1999	60.40	78.28
2000	53.86	78.62
2001	50.70	71.80
2002	38.54	71.84
2003	45.12	76.63

around 12.5 percent for the sector as a whole. This is largely a result of increased technology change (8.4 percent) but there have also been gains in technical efficiency (3.8 percent). There is a wide variation in Malmquist productivity change across the types of FE provider: general FE/tertiary colleges have seen only a 4.4 percent increase in productivity between 1999 and 2003, compared with 21.3 percent for the eight specialist colleges in the sample, and nearly 30 percent for external and specialist institutions. In all cases, the productivity gains that we observe over the entire period (1999–2003) are dominated by technology change. Possible insights into why groups of institutions in the same sector should experience such differences in the size of productivity gains over the period are investigated in the multivariate statistical analysis in the next section.

TABLE 4
Spearman's correlations of the FE provider efficiency scores

	1999	*2000*	*2001*	*2002*
2000	0.771*			
2001	0.635*	0.788*		
2002	0.325*	0.427*	0.562*	
2003	0.346*	0.414*	0.498*	0.769*

*Coefficients significant at the 1% level.

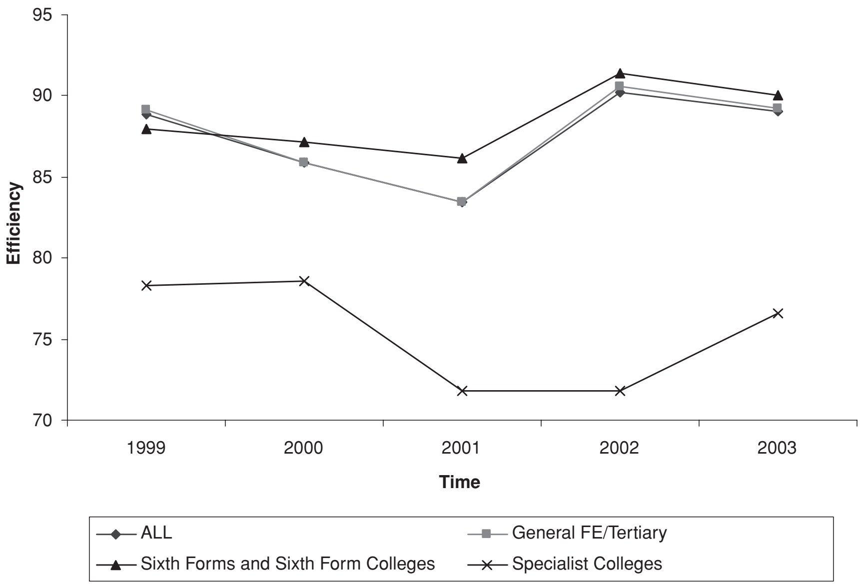


Fig. 1. Mean VRS efficiency scores by type of provider.

IV.3 Multivariate analysis

Table 6 reports the estimates from the panel random effects Tobit model applied to all providers.[7] The results indicate that providers with a higher percentage of female students have higher efficiency scores: a one-point increase in the percentage of female students would

[7] For comparison, a pooled cross-section model and panel models with (respectively) fixed and random effects are also run with the efficiency score (treated as a continuous dependent variable with no limits) as the dependent variable. The conclusions are the same as those derived from the Tobit random effects model (with the exception that the local unemployment rate and the average age of teachers are not significant in the pooled model) and so they are not reported here.

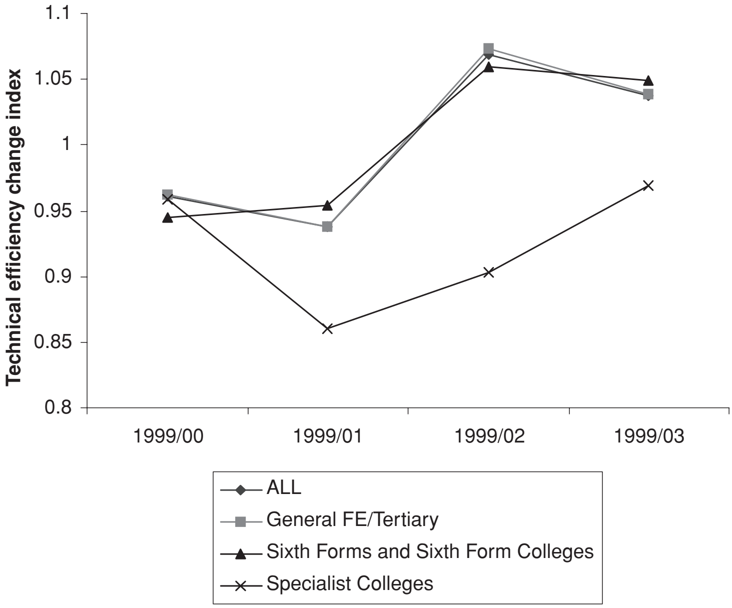
TABLE 5

Technical efficiency, technology and Malmquist productivity change calculated using the base year approach: weighted geometric means

	Technical efficiency change (E)	*Technology change (T)*	*Malmquist productivity change (M)*
All FE providers			
1999/00	0.961	1.026	0.987
1999/01	0.938	1.046	0.981
1999/02	1.068	1.052	1.123
1999/03	1.038	1.084	1.125
General FE/tertiary colleges			
1999/00	0.963	1.016	0.979
1999/01	0.938	1.036	0.972
1999/02	1.073	1.041	1.117
1999/03	1.038	1.069	1.110
Sixth forms/sixth form colleges			
1999/00	0.944	1.156	1.093
1999/01	0.954	1.184	1.129
1999/02	1.059	1.193	1.262
1999/03	1.049	1.237	1.298
Specialist colleges			
1999/00	0.959	1.058	1.014
1999/01	0.868	1.108	0.956
1999/02	0.903	1.093	0.991
1999/03	0.969	1.248	1.213

increase the efficiency score by 0.29 percentage points. The percentage of students from non-white ethnic backgrounds also tends to increase the efficiency score of the FE provider. In particular, a one-point increase in the percentage of Pakistani/Bangladeshi students is associated with a 0.26 percentage point increase in the efficiency score. Statistically significant, positive, effects are also found with respect to the Black minority and the percentage not UK-born variables, although these are only significant at the 10 percent level. These findings are consistent with other research, which shows that girls out-perform boys in examinations in FE and that students from ethnic minorities have a higher propensity to continue in FE to close the so-called ‘qualification gap’ between themselves and their white counterparts (Bradley and Taylor, 2004; Andrews *et al.*, 2006; Bradley and Lenton, 2007). In addition, a larger percentage of mature students (i.e., aged over 19) significantly reduces the predicted efficiency score (a one-point increase in the percentage of students aged 19 or over results in a 0.30 percentage point reduction in the efficiency score), which may be because these students are more likely to drop out.

Technical efficiency change: Base year approach



Technology change: base year approach

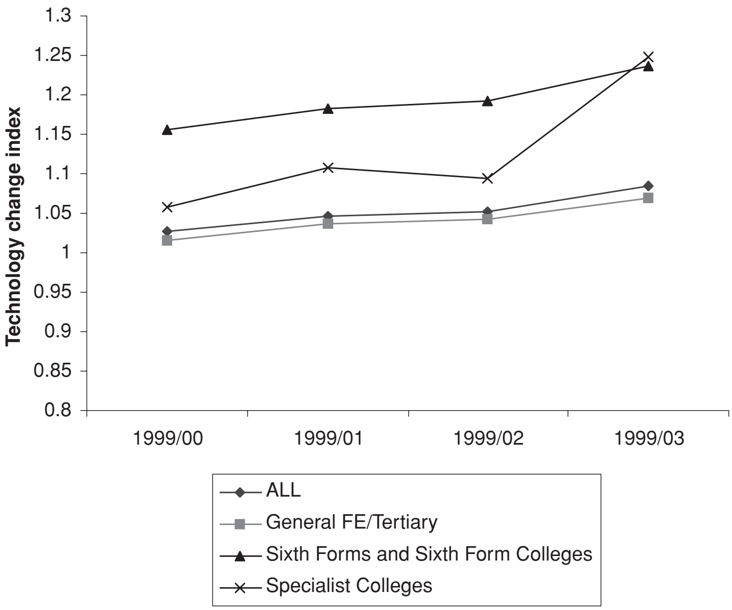


Fig. 2. Technical efficiency, technology and Malmquist productivity change indices.

Malmquist productivity change: base year approach

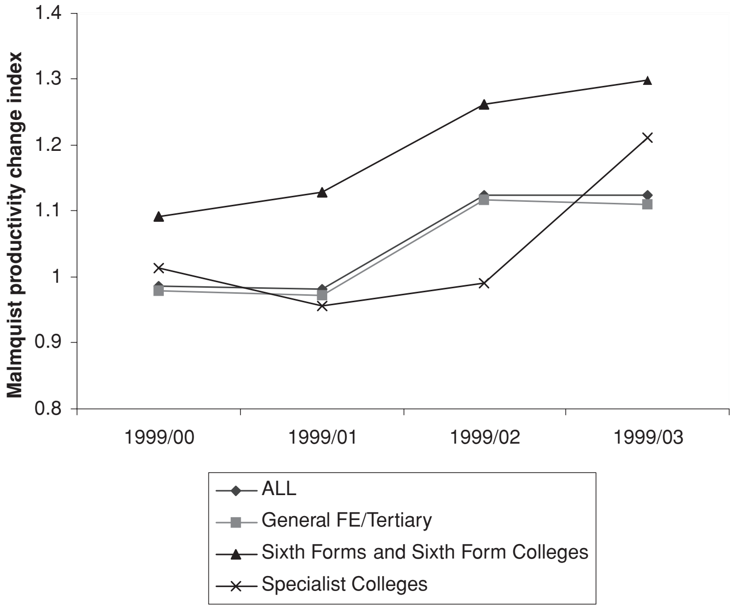


Fig. 2. (*Continued*)

Clearly, the effects of the student composition are small and difficult for FE providers to manipulate in order to raise efficiency. However, they do imply that FE providers should investigate strategies to improve retention rates and achievement amongst the base group – white males.

With regard to the environmental variables, a higher local unemployment rate is associated with a higher efficiency score, as expected. A one-point increase in the unemployment rate is associated with an additional 1.24 percentage points on the efficiency score for FE providers. There is no statistically significant relationship between efficiency scores and the proportion of unqualified adults in the locality.

With regard to teaching-related variables, the average age of teachers, a proxy for experience, has a positive effect on efficiency, and this is non-linear peaking at an average age of around 45 years. The percentage of staff who are on permanent and fixed term contracts, compared to casual or agency staff, also has a positive effect, as does, surprisingly, the ratio of students to staff. In contrast, the ratio of teachers to 'support' staff (administrative, technical, clerical and service staff) significantly reduces the efficiency, which implies that efficiency is improved where teaching staff are supported in their non-teaching duties.

Table 6 also shows that the average sixth form college is predicted to have lower efficiency than the average general FE/tertiary college

TABLE 6

The 'determinants' of FE provider efficiency scores

	All FE providers			*General/tertiary*			*Sixth form*		
	Coef.	*s.e.*	*Prob.*	*Coef.*	*s.e.*	*Prob.*	*Coef.*	*s.e.*	*Prob.*
Female	0.294	0.103	0.004	0.428	0.123	0.001	0.581	0.181	0.001
Pakistani/Bangladeshi	0.263	0.130	0.043	0.688	0.348	0.048	0.093	0.102	0.361
Black	0.243	0.137	0.077	0.241	0.159	0.130	0.270	0.336	0.421
Indian	0.186	0.156	0.234	−0.374	0.282	0.184	0.343	0.127	0.007
Other ethnic	0.091	0.167	0.587	0.132	0.210	0.528	0.141	0.229	0.539
Mature	−0.304	0.052	0.000	−0.236	0.132	0.075	−0.358	0.053	0.000
Immigrant	0.599	0.253	0.018	0.597	0.268	0.026	1.579	1.057	0.135
Learning disabilities	−0.036	0.028	0.206	−0.038	0.034	0.262	−0.019	0.041	0.641
Local unemployment rate	1.240	0.442	0.005	1.369	0.540	0.011	1.183	0.681	0.083
Unqualified rate	0.139	0.208	0.503	−0.048	0.255	0.849	0.084	0.301	0.779
Average age of teachers	14.270	8.010	0.075	40.955	14.618	0.005	−11.117	11.825	0.347
Age squared	−0.156	0.092	0.091	−0.460	0.164	0.005	0.136	0.139	0.326
Teacher–student ratio: Pakistani	−0.053	0.244	0.830	0.061	0.265	0.818	−1.590	0.635	0.012
Teacher–student ratio: Black	−0.060	0.169	0.722	0.044	0.250	0.860	−0.221	0.207	0.285
Teacher–student ratio: Indian	0.013	0.018	0.461	0.012	0.018	0.494	−0.114	0.279	0.683
Teacher–student ratio: other	0.047	0.079	0.553	0.060	0.080	0.454	−0.895	0.764	0.241

Permanent/fixed term	0.074	0.028	0.008	0.055	0.031	0.071	0.122	0.083	0.140
Teacher–manager ratio	−0.040	0.033	0.221	−0.045	0.034	0.180	−0.034	0.088	0.698
Teacher–support staff ratio	−3.759	1.058	0.000	−4.886	1.357	0.000	−3.444	1.369	0.012
Student–teacher ratio	0.264	0.044	0.000	0.280	0.051	0.000	0.438	0.148	0.003
Sixth form colleges	−5.418	2.905	0.062						
Specialist colleges	−6.869	4.267	0.107						
Year 2000	−2.036	0.982	0.038	−3.364	1.180	0.004	−0.393	1.601	0.806
Year 2001	−5.273	1.050	0.000	−7.260	1.284	0.000	−1.994	1.703	0.242
Year 2002	2.258	1.052	0.032	1.709	1.304	0.190	2.318	1.702	0.173
Year 2003	1.921	1.090	0.078	0.892	1.381	0.518	2.898	1.683	0.085
Constant	−249.984	174.290	0.151	−841.759	325.148	0.010	271.823	252.499	0.282
Sigma u (s.e.)		9.082 (0.628)			9.783 (0.799)			4.609 (0.823)	
Sigma e (s.e.)		7.889 (0.244)			7.706 (0.287)			6.524 (0.393)	
Rho (s.e.)		0.570 (0.038)			0.617 (0.043)			0.333 (0.088)	
Observations		849			576			241	
Providers		186			122			57	
Censored observations		169			106			57	

Note: See the Appendix for full definition of variables.

by 5.4 percentage points, and the average specialist college is predicted to have lower efficiency than the average general FE/tertiary college by 6.9 percentage points (but note that the latter result is based on a sample of eight). In the case of the former result, it should be noted that the DEA efficiency scores reported in Table 5 exhibit little difference in performance between sixth form colleges and general FE/tertiary colleges, suggesting that it is important to control for other determinants of efficiency.

Finally, the results regarding the year dummies come as no surprise in light of the time series patterns exhibited in Figure 1. Efficiency scores in 2000 and 2001 are significantly lower than in 1999, while the converse is the case for 2002 and 2003. Thus, the differences in efficiency scores over time appear not to be caused by inter-temporal differences in the other determinants of efficiency.

Also presented in Table 6 are the results of estimating the panel Tobit models for each type of college separately. The results for general FE/tertiary colleges are very similar to those for the aggregate model. For sixth forms and sixth form colleges, there are some slight differences. With regard to student and environmental variables, the results are similar to those for the whole sample, with the exception of the ethnic background of the students. Only the Indian minority variable is a significant determinant of efficiency amongst sixth forms and sixth form colleges. There are also some obvious differences with respect to the teaching-related variables. The average age of teachers and the percentage of staff who are on permanent and fixed term contracts are not significant determinants of efficiency amongst sixth form and sixth form colleges, while the ratio of the percentage of Pakistani and Bangladeshi teachers to the percentage of Pakistani and Bangladeshi students has a highly significant negative effect on efficiency. Finally, once the other determinants of efficiency are taken into account, there are no significant differences in efficiency over time, suggesting that the inter-temporal pattern of efficiency observed in Figure 1 is explained by similar inter-temporal differences in the determinants of efficiency for sixth form and sixth form colleges. This is not the case for general FE/tertiary colleges.

The estimates reported in Table 7 are obtained from an OLS regression with, respectively, M, E and T as the dependent variables, each of which are calculated using the base year method.[8] Since these dependent variables measure change over time, each explanatory variable has been constructed as the change in the variable between the base year (1999) and year t ($t = 2000$ to 2003).

[8] Note that the index has been converted to a percentage (by subtracting from 1 and multiplying by 100) to simplify the interpretation of the coefficient on the explanatory variables.

TABLE 7

The determinants of changes in productivity (base year approach)

	M			*E*			*T*		
	Coef.	*s.e.*	*Prob. value*	*Coef.*	*s.e.*	*Prob. value*	*Coef.*	*s.e.*	*Prob. value*
ΔFemale	0.691	0.220	0.002	0.374	0.253	0.141	0.358	0.253	0.160
ΔPakistani/Bangladeshi	0.706	0.533	0.187	0.634	0.268	0.019	−0.252	0.404	0.534
ΔBlack	−0.278	0.376	0.461	0.110	0.190	0.562	−0.373	0.365	0.309
ΔIndian	0.752	0.593	0.206	−0.134	0.281	0.634	0.936	0.590	0.115
ΔOther	0.264	0.377	0.485	0.039	0.264	0.883	0.238	0.322	0.461
ΔMature	−0.453	0.224	0.045	−0.036	0.157	0.821	−0.423	0.191	0.028
ΔImmigrant	1.706	0.518	0.001	1.382	0.432	0.002	0.239	0.249	0.340
ΔLearning disabilities	0.046	0.054	0.390	−0.044	0.032	0.172	0.107	0.040	0.008
ΔUnemployment rate	1.268	0.888	0.156	1.296	0.811	0.112	−0.098	0.634	0.877
ΔUnqualified rate	0.055	0.658	0.933	−0.186	0.570	0.745	0.304	0.467	0.516
ΔStudent	−0.002	0.001	0.052	−0.002	0.001	0.060	−0.000	0.001	0.925
ΔStudents^2	0.000	0.000	0.202	0.000	0.000	0.180	−0.000	0.000	0.779
ΔAverage age of teachers	0.300	1.093	0.784	1.168	0.955	0.223	−1.314	1.040	0.208
ΔAge^2	0.000	0.000	0.686	0.000	0.000	0.279	−0.000	0.000	0.220

TABLE 7
(*Continued*)

	M			*E*			*T*		
	Coef.	*s.e.*	*Prob. value*	*Coef.*	*s.e.*	*Prob. value*	*Coef.*	*s.e.*	*Prob. value*
ΔTeacher–student ratio: Pakistani	0.155	0.440	0.726	0.144	0.375	0.701	−0.009	0.320	0.977
ΔTeacher–student ratio: Black	0.314	0.570	0.583	0.072	0.294	0.808	0.356	0.351	0.312
ΔTeacher–student ratio: Indian	0.017	0.028	0.542	0.005	0.029	0.858	0.008	0.008	0.326
ΔTeacher–student ratio: other	0.223	0.078	0.005	0.144	0.090	0.111	0.063	0.048	0.187
ΔPermanent/fixed term	0.031	0.060	0.601	0.020	0.062	0.750	0.007	0.044	0.873
ΔRatio of teachers–managers	−0.095	0.053	0.074	−0.099	0.058	0.089	0.023	0.043	0.586
ΔRatio of teachers–support staff	−13.218	3.115	0.000	−12.532	2.915	0.000	0.204	1.847	0.912
ΔStudent–teacher ratio	0.382	0.067	0.000	0.173	0.058	0.003	0.181	0.054	0.001
Sixth form colleges	14.523	2.612	0.000	−3.032	2.001	0.132	19.022	2.958	0.000
Specialist colleges	−4.621	6.094	0.449	−10.467	7.816	0.182	7.383	4.216	0.082
Base year 1999–2001	−0.309	1.221	0.800	−2.669	1.044	0.011	2.934	0.976	0.003
Base year 1999–2002	13.613	2.099	0.000	8.797	1.692	0.000	4.120	1.533	0.008
Base year 1999–2003	16.208	1.969	0.000	8.934	1.684	0.000	6.294	1.406	0.000
Constant	−0.628	1.523	0.681	−1.051	1.433	0.464	0.398	1.081	0.713
R^2	0.453			0.317			0.372		

Notes: Sample comprises 626 observations and 163 providers. Δ denotes change in values between base year (1999) and year t ($t = 2000, \ldots, 2003$). M, E and T are defined in the text. Estimates obtained from a standard regression with robust standard errors to control for clustering of observations by provider.
See the Appendix for full definition of variables.

An increase in the proportion of female students significantly increases the overall productivity of a college. This is a consequence of the effect of the gender profile on both technical efficiency change and technological change. Similarly, increasing the ratio of students to staff increases overall productivity, and this is a consequence of the positive effect on both technical efficiency and technological change. An increase in the proportion of students from outside the UK increases overall productivity, due to its positive effect on technological change.

The size of the college, proxied by student numbers,[9] is included in the analysis of productivity change because these indices are calculated from constant returns to scale DEA efficiencies. Increasing size has a negative (non-linear) effect on overall productivity, and this is entirely a consequence of its effect on technical efficiency change, suggesting the presence of diseconomies of scale. Similarly, increasing the ratio of teachers to support staff (and to a lesser extent the ratio of teachers to managers) has negative effects on overall productivity caused entirely by their (negative) effect on technical efficiency change. In addition, overall productivity falls (predominantly because of a fall in technological efficiency) as the proportion of students aged over 19 increases.

The significance of some of the sixth form college dummy variables reveals some differences between these colleges and general FE/tertiary colleges in their level and source of productivity change. Sixth form colleges have Malmquist productivity change which is more than 14 percentage points higher than for general FE/tertiary colleges. This compares with only a 1 percentage point difference before taking into account the explanatory variables (see Table 5). However, the 19 percentage point difference in technological change identified by the regression analysis is similar in magnitude to the raw difference in Table 5. Further analysis of the determinants of productivity change and its components by type of college is beyond the scope of this paper.

V. CONCLUSIONS

In the recent Government White Paper on Further Education (DfES, 2006), it is clear that poor performance in the FE sector will no longer be tolerated. Providers will be expected to monitor their own performance and improve areas of weakness. Specifically, systems will be created to eliminate failure and help the best-performing providers spread their influence. Moreover, the development of performance indicators that allow comparisons and provide targets to achieve improvements will

[9] Size of college was not included in the analysis of technical efficiencies, because size was already controlled for by using a VRS DEA.

be crucial. In an attempt to provide some insights into efficiency and productivity in a sector that has hitherto been unexplored, this analysis applies DEA and general distance function analysis to a 5-year sample of FE colleges.

The study finds that mean efficiency for the sector as a whole has varied between 83 and 90 percent over the 5-year period. This level of efficiency is a little lower than that typically found in studies of the efficiency of non-profit sectors such as the higher education sector where efficiency is around 94 percent (Johnes, 2006) and the health sector where mean efficiency is also over 90 percent (Byrnes and Valdmanis, 1994). Despite the general improvement in efficiency in the sector as a whole, there are still wide variations in efficiency between individual institutions.

A multivariate analysis shows that the level of efficiency in FE colleges is positively affected by the proportions of female students and non-white students, and negatively associated with the proportion of mature students. The local unemployment rate, the percentage of permanent and fixed term staff and the student–teacher ratio also raise efficiency, whereas the ratio of teachers to support staff reduces efficiency. In addition, there are statistically significant differences in efficiency score by type of provider and over time, once other factors have been taken into account.

The Malmquist productivity indices indicate that productivity in the FE sector has increased over the entire period 1999–2003 by around 12 percent. This is due both to increasing technology change (8 percent), possibly caused by innovations in teaching methods, and (to a lesser extent) increasing technical efficiency change (nearly 4 percent), possibly caused by improved use or management of existing resources. Both the level and the components of productivity change over the period appear to vary by type of provider. Sixth forms and sixth form colleges have the highest productivity change (30 percent) while general FE/tertiary colleges have the lowest productivity change (11 percent). In all cases, the technology change is stronger than the technical efficiency change.

These results are interesting because they represent a first attempt at gaining a better understanding of efficiency and productivity in the FE sector. The multivariate analysis of both the level of efficiency and productivity change suggests that FE providers that are inefficient will have difficulty in becoming efficient. However, the results do suggest that supporting white males and increasing administrative support for teachers are ways in which efficiency can be increased. Little can be done by the provider about the local environmental context.

The provider has more control over staff composition and deployment and this may well have an effect on its efficiency. However, the sample is considerably reduced by poor data particularly in the case of staff inputs. There is therefore a need for improved data collection in the FE sector. This would facilitate a more thorough analysis of the possible determinants of efficiency and productivity, and hence lead to the development of additional strategies for improving efficiency in the FE sector.

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APPENDIX: VARIABLE DEFINITIONS

Variable name	*Variable definition*
Student	Number of students in college *j* at time *t*
Notwp	Number of students in college *j* who do not qualify for widening participation uplift factor at time *t*
Teach	Number of teachers in college *j* at time *t*
Qualteach	Number of teachers with qualified teaching status in college *j* at time *t*
Retnum	Number of students who have not withdrawn from a college *j* during time *t* (measured at the student level)
Achieve	Number of aimed for qualifications that are achieved (measured at the level of the qualification) in college *j* at time *t*
Female	Percentage of female students in college *j* at time *t*
Pakistani/Bangladeshi	Percentage of students of Pakistani or Bangladeshi origin in college *j* at time *t*
Black	Percentage of students of Afro-Caribbean origin in college *j* at time *t*
Indian	Percentage of students of Indian origin in college *j* at time *t*
Other	Percentage of students of origin other than Pakistani, Bangladeshi, Afro-Caribbean, Indian or white in college *j* at time *t*
Mature	Percentage of students aged 19 or more in college *j* at time *t*
Immigrants	Percentage of students born outside the UK in college *j* at time *t*
Learning disabilities	Percentage of students with learning disabilities in college *j* at time *t*
Local unemployment rate	Unemployment rate in the Local Authority District (LAD) in which the college is located at time *t*
Unqualified rate	Percentage of the workforce with no qualifications in the LAD in which the college is located, 2001
Average age of teachers	Average age of teaching workforce in college *j* at time *t*
Age squared	Average age squared
Teacher–student ratio: Pakistani	Percentage of teachers of Pakistani/Bangladeshi origin in college *j* at time *t*/percentage of students of Pakistani/Bangladeshi origin in college *j* at time *t*
Teacher–student ratio: Black	Percentage of teachers of Afro-Caribbean origin in college *j* at time *t*/percentage of students of Afro-Caribbean origin in college *j* at time *t*
Teacher–student ratio: Indian	Percentage of teachers of Indian origin in college *j* at time *t*/Percentage of students of Indian origin in college *j* at time *t*

Variable name	*Variable definition*
Teacher–student ratio: other	Percentage of teachers of other origin in college *j* at time *t*/percentage of students of other origin in college *j* at time *t*
Permanent/fixed term	Percentage of teaching staff on permanent or fixed term contracts in college *j* at time *t*
Teacher–manager ratio	Number of teachers/number of managers in college *j* at time *t*
Teacher–support staff ratio	Number of teachers/number of support staff (i.e., laboratory technicians, librarians, etc.) in college *j* at time *t*
Student–teacher ratio	Number of students in college *j* at time *t*/number of teachers in college *j* at time *t* (average class size)
Sixth form colleges	Dummy variable to indicate sixth form college
Specialist colleges	Dummy variable to indicate specialist college
t	Year
j	College or DMU