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Some university students are more equal than others: Efficiency evidence from England

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Abstract

This paper estimates the efficiency of students in English universities using Data Envelopment Analysis (DEA) and a new dataset which is able to capture the behaviour of university students. Two output variables are specified: the classification of a university degree, and student satisfaction. Three input variables are specified: teaching hours, private study and entry qualifications. The results reveal that university students differ in terms of the efficiency with which they use inputs in generating good degrees and satisfaction. Students in some post-92 universities may be more efficient than students in some pre-92 universities.

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1. Introduction

The university sector in England is large and diverse. As of August 2007 there were 132 universities employing a total of over 110,000 full-time academic staff, with over 1 million full-time undergraduates and a total income of over £21 billion (data from the Higher Education Statistical Agency (HESA)). Universities range from the long-established universities of Oxford and Cambridge, to new universities that have only been recently granted university status as a result of the Further and Higher Education Act of 1992 (known as post-92 universities). The subjects taught by universities are also diverse, from the traditional Politics, Philosophy and Economics, to the modern Computer Game Design.

Such diversity of institutions and subjects may be assumed to attract a diverse group of students, who may be expected to be diverse in terms of their abilities. This paper addresses this diversity in student abilities. Specifically, the efficiency of students in terms of the degree class obtained and student satisfaction is investigated, given the inputs that they put into their studies, using Data Envelopment Analysis (DEA). A new dataset of 78 English universities for which consistent data is available for 2006 and 2007 is employed.

The main results of the study are the following. There is evidence of substantial variation in student efficiency across universities. Post-92 universities have lower VRS (Variable Returns to Scale) technical efficiency than pre-92 universities. Nevertheless, there is sufficient overlap in efficiency between post-92 and pre-92 universities for us to conclude that the traditional binary divide between these two groups of universities may no longer be valid, at least in terms of student efficiency.

Previous work on the efficiency of university students in the production of their degrees includes Johnes (2006a, b). In these papers Johnes uses DEA to estimate the efficiency of students in UK universities using individual-level data. The use of individual-level data allows Johnes to investigate the role of individual-level variables such as age and gender on students' efficiency which we are unable to replicate with our university-level dataset. However, our dataset includes direct measures of student effort levels and teaching quality and quantity, which are unavailable in Johnes's data. This allows us to more directly capture the determinants of university degree performance.

In addition, this paper relates to three strands of literature. First, there has been much work on the determinants of educational success in higher education and the reasons for dropping out of higher education. This relates to the literature on educational production such as Lazear (2001) and Todd and Wolpin (2003) and primarily adopts a regression-based approach, using data at either the individual or institutional level. However, this approach does not (rather, is unable to) address the question of whether students are efficient in terms of producing degree performance. Naylor and Smith (2004) survey this literature; more recent work includes Martins and Walker (2005), Stanca (2006), and Arulampalam *et. al.* (2007).

A second strand of literature is that on the efficiency of universities. This literature focuses on universities as economic entities and whether they are efficient at producing output in terms of student degrees or research, using as inputs the financial and human resources available to the university. Methods used include DEA and stochastic frontier analysis. This literature nevertheless differs from the present paper in its focus on the performance of the university rather than the performance of students in university. J. Johnes (2004) surveys this literature; more recent examples include Johnes *et. al.* (2005) and Johnes (2006c, 2008).

A third strand of related literature (which is closely related to the second strand) is the literature on the estimation of multi-product cost functions of universities. This literature explores the relationship between the inputs and outputs of universities by estimating the cost function using regression analysis, and is surveyed by Cohn and Cooper (2004); see also Johnes *et. al.* (2005).

The next section discusses the method of DEA used in this paper. Section 3 discusses the data used, and Section 4 presents the results, and Section 5 concludes.

2. Methods

This paper uses DEA to explore the relative efficiency of students in different English universities. The exposition in this section follows that of Coelli (1996) and Coelli *et. al.* (2005). We use the output-orientated DEA model, where the objective of the Decision-Making Unit (DMU) is to maximise outputs given the available level of inputs. In this paper students are assumed to have the dual objective of maximising their degree classification and their satisfaction, subject to the amount of effort they put into their studies and their prior background.

First consider the constant-returns-to-scale (CRS) model. Let there be K inputs and 2 outputs on each of N DMUs. For the i^{th} DMU these are represented by the vectors x_i and y_i respectively. The K x N input matrix X and the 2 x N output matrix Y represent the data of all N DMUs. The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier.

The mathematical form of this problem is:

$$\max_{\theta,\lambda} \theta$$
$$s.t. \qquad -\theta y_i + Y\lambda \geq 0, \qquad x_i - X\lambda \geq 0, \qquad \lambda \geq 0 \qquad (1)$$

Where θ is a scalar and λ is a N x 1 vector of constants. The value of $1/\theta$ obtained will be the efficiency score for the i^{th} DMU. It will satisfy $\theta \geq 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient DMU; that is, a DMU where the outputs cannot be increased without an increase in inputs. The linear programming problem must be solved for each DMU in the sample and a value of θ obtained for each DMU.

However, the CRS assumption is only appropriate when all DMUs are operating at an optimal scale. The use of the CRS specification when not all DMUs are operating at the optimal scale will result in measures of technical efficiency which are confounded by scale efficiencies. The use of the variable-returns-to-scale (VRS) model will permit the calculation of technical efficiency excluding these scale effects.

The CRS linear programming problem can be modified to account for VRS by adding the convexity constraint $N1'\lambda = 1$ to equation (1) to provide:

$$\max_{\theta,\lambda} \theta$$
$$s.t. \qquad -\theta y_i + Y\lambda \geq 0, \qquad x_i - X\lambda \geq 0, \qquad N1'\lambda = 1, \qquad \lambda \geq 0 \qquad (2)$$

Where N1 is an N x 1 vector of ones. This approach forms a convex hull of intersecting planes which envelop the data points more tightly than the CRS hull and thus provides technical efficiency scores which are greater than or equal to those obtained using the CRS model. If the technical efficiency scores for a DMU are different between CRS and VRS models, this indicates that the DMU has scale inefficiency, and the scale inefficiency can be calculated from the ratio of the CRS and VRS technical efficiency scores.

3. Data

The data used in this paper comes from two main sources. Data on the student experience in English universities come from the two Higher Education Policy Institute (HEPI) reports by Bekhradnia *et. al.* (2006) and Sastry and Bekhradnia (2007). In these studies, the authors conducted surveys of first and second year students in English universities. In each year there were over 14,000 respondents from a sample of over 23,000. These respondents are distributed across 132 universities and all subject areas; see Bekhradnia *et. al.* (2006) and Sastry and Bekhradnia (2007) for details of the sample.

The HEPI surveys ask students questions regarding the workload that they experience, including the number of teaching hours, private study, outside employment, use of specialist equipment, and the level of satisfaction. Most questions (and all of those used in the present paper) were repeated in both surveys. Sastry and Bekhradnia (2007) report that the results of the two surveys reveal only very small differences which they attribute to random variation or differences in approach.

The present study uses the results of both surveys. The individual responses are aggregated to the university level. As a result of this aggregation and allowing for missing observations from other data sources, the final sample used in this study consists of a balanced panel of 78 universities for two years (2006 and 2007). Two input variables are obtained from the HEPI reports: the average number of teaching hours, given by the average number of hours attended, and the average number of hours of private study.

The second main data source used in this study is the National Student Survey (NSS), conducted by HEFCE (Higher Education Funding Council for England) in collaboration with the NUS (National Union of Students). This annual survey, conducted since 2005, asks students a set of questions relating to teaching, assessment and feedback, academic support, organisation and management, learning resources, and personal development. The question we use from the NSS is Question 22: “Overall, I am satisfied with the quality of my course”. The response is on a five-point scale, with higher values representing greater satisfaction. We use the average of this as a summary measure of the output of student satisfaction.

The NSS data on the HEFCE website (http://www.hefce.ac.uk/) includes information on the median entry scores of students by university. English students entering English universities almost always take the GCE A-level exam, taking three or four subjects. These exams are graded from A to E, with an A being worth 120 points, and each lower grade being worth 20 points less than the grade above, so that the lowest grade E is worth 40 points. Students with different entry qualifications (e.g. overseas students) have their qualifications converted into points on this scale. The median entry score is used as the measure of student entry grades.

Finally, the NSS data also includes information on the final degree outcomes by university and subject. In England, almost all degrees are classified as first class honours, upper second class honours, lower second class honours, third class honours, or ordinary or unclassified degrees. The NSS data gives information on the percentage of students that achieve each classification level. A “good degree” is defined as upper second class honours or first class honours. The percentage of students who achieve a "good degree" is used as one of the outputs.[1]

Universities in the UK are prevented from giving good degrees to students who do not deserve them, by a system of external examiners who moderate university degrees. As a result of this moderation, degree results are not marked according to any distributional requirements. Also, whilst there is concern over grade inflation over time (see the survey in G. Johnes (2004)), it may be argued that this is much less of a problem for the two year sample used here than for one with a longer time dimension.

The use of average values as inputs and the percentage of good degrees as the output poses no difficulties of the type discussed in Dyson *et. al.* (2001) since all inputs and outputs are averages or percentages. The use of average values does however change the interpretation of the results. The presence of scale economies in this study, for example, would mean that an increase in average inputs would lead to a greater than proportional increase in the average outputs as measured by the percentage of good degrees and average student satisfaction.

A potential alternative model would be to model the efficiency of university students in moving into employment, since it may be argued that this represents the true output of a university. However, graduate employment is as much a result of university effort and reputation as it is of students' effort which is the focus of the present paper. This does not preclude the development of a model to address university efficiency in securing graduate employment, but this is beyond the scope of the present paper.

Table 1: Descriptive statistics.

	All universities		**Pre-1992 universities**		**Post-1992 universities**	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
% good degree	56.092	9.941	64.232**	7.749	50.430	6.910
Attended hours	12.515	1.758	12.906*	2.188	12.244	1.329
Private study	12.257	1.728	12.638*	1.352	11.991	1.910
Satisfaction	3.981	0.161	4.087**	0.138	3.907	0.133
Median A-level	292.82	74.21	364.29**	52.45	243.09	37.19

Notes: This table shows averages across 2006 and 2007. The number of universities N = 78 for all universities, N = 32 for pre-1992 universities, and N = 46 for post-1992 universities. *, ** indicates that the means for pre-1992 and post-1992 universities are significantly different from one another at the 5% and 1% level respectively.

Table 1 presents the descriptive statistics of the dataset, for all universities in the sample, and for pre-1992 and post-1992 universities. Pre-1992 universities are institutions that had university status prior to 1992. Post-1992 universities are institutions that were awarded university status as a result of the Further and Higher Education Act of 1992; these are primarily former polytechnics. In our sample of 78 universities there are 32 pre-1992 universities and 46 post-1992 universities; Appendix A lists the universities included in the sample.

Over half of all students obtained a good degree, with pre-1992 universities having a significantly higher percentage of students with good degrees. Pre-1992 universities also

[1] There are some subject areas such as Medicine where degree classifications are not used. These subjects have been dropped from the sample prior to aggregation.

offered significantly more classroom hours, and their students spent significantly more hours on private study. Students at pre-1992 universities also reported higher levels of satisfaction (the difference is small but statistically significant), and had much higher A-level entry scores as well.

4. Results of DEA

In this paper we calculate the efficiency of students in English universities in 2006 and 2007 using the method of DEA as outlined above, using as outputs the percentage of students graduating with good degrees as defined above, and the average student satisfaction. Two models of efficiency are estimated. In the first model (the two-input model), we use as inputs the number of hours of private study and classroom hours attended from HEPI. In the second model (the three-input model), in addition to these two inputs, we also include the A-level entry scores as a third input. The analysis is performed for both the full sample of universities, and for the subsamples of pre-1992 and post-1992 universities separately.

Table 2: Efficiency over time.

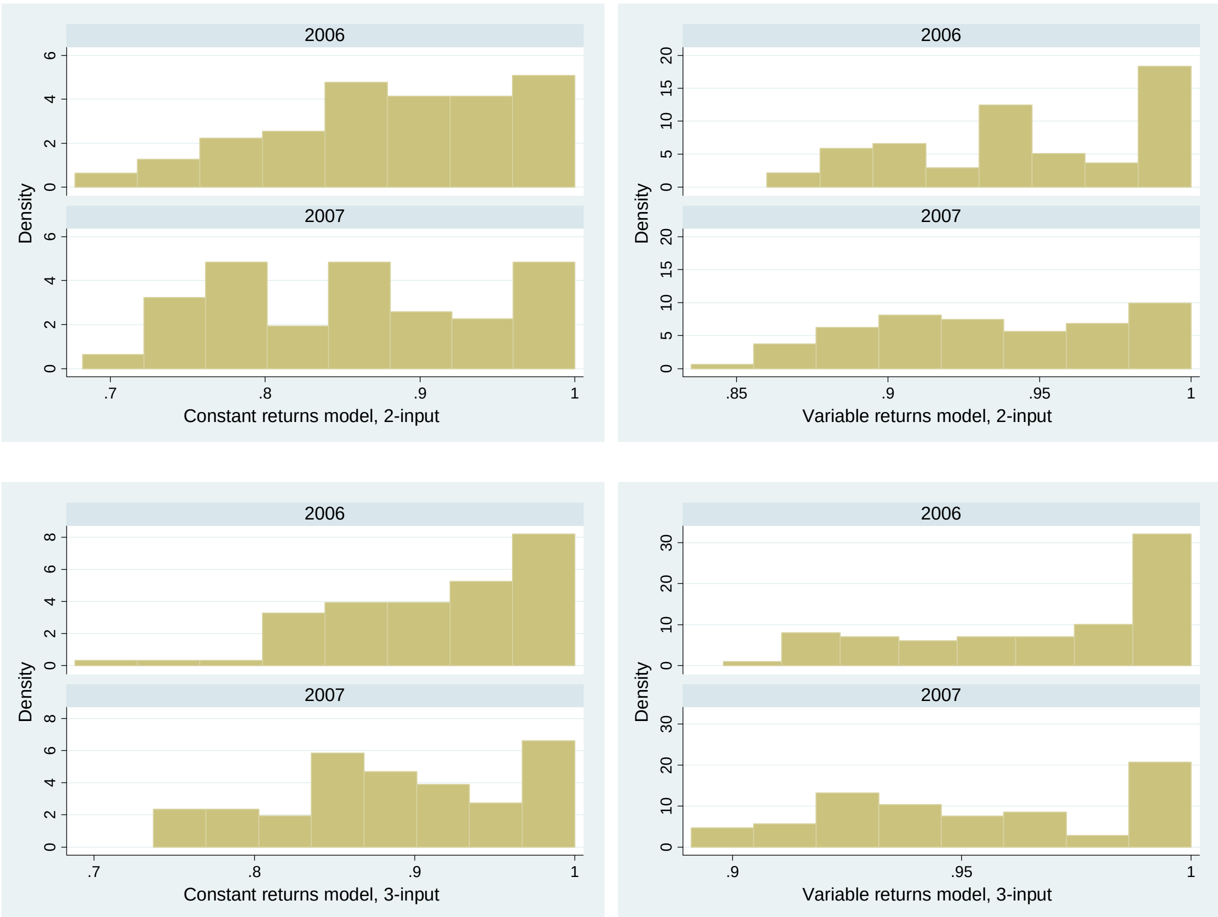
Panel A: DEA applied to all universities							
		CRS technical efficiency			**VRS technical efficiency**		
Year	**Model**	**All**	**Pre-1992**	**Post-1992**	**All**	**Pre-1992**	**Post-1992**
2006	2-input	0.8846	0.8976	0.8755	0.9470	0.9713	0.9301**
	3-input	0.9170	0.9042	0.9259	0.9697	0.9769	0.9647*
2007	2-input	0.8585	0.8788	0.8444	0.9364	0.9601	0.9200**
	3-input	0.8909	0.8843	0.8956	0.9543	0.9637	0.9478*
		Scale efficiency			**Returns to scale**		
Year	**Model**	**All**	**Pre-1992**	**Post-1992**	**IRS**	**CRS**	**DRS**
2006	2-input	0.9334	0.9233	0.9405	5	10	63
	3-input	0.9454	0.9250	0.9597**	7	15	56
2007	2-input	0.9156	0.9141	0.9166	4	8	66
	3-input	0.9329	0.9165	0.9443*	3	13	62
Panel B: DEA applied to pre-1992 and post-1992 universities separately							
		CRS technical efficiency			**VRS technical efficiency**		
Year	**Model**	**All**	**Pre-1992**	**Post-1992**	**All**	**Pre-1992**	**Post-1992**
2006	2-input	0.8922	0.9033	0.8845	0.9663	0.9719	0.9625
	3-input	0.9321	0.9384	0.9277	0.9767	0.9858	0.9704**
2007	2-input	0.8772	0.8927	0.8664	0.9565	0.9630	0.9519
	3-input	0.9101	0.9245	0.9002	0.9645	0.9733	0.9584*
		Scale efficiency			**Returns to scale**		
Year	**Model**	**All**	**Pre-1992**	**Post-1992**	**IRS**	**CRS**	**DRS**
2006	2-input	0.9227	0.9287	0.9184	2	11	65
	3-input	0.9541	0.9516	0.9558	4	21	53
2007	2-input	0.9160	0.9258	0.9091	6	11	61
	3-input	0.9429	0.9490	0.9387	6	16	56

Notes: *, ** indicate that the pre-1992 and post-1992 averages are significantly different from each other at the 5% and 1% level. N = 32 for pre-1992 universities, and N = 46 for post-1992 universities. The values for returns to scale are the number of universities which exhibit IRS, CRS and DRS.

Table 2 reports the means of the results for the DEA (results for individual universities are available from the authors upon request). The average efficiency relative to the efficiency frontier is quite high. Going from the two-input to the three-input model increases both CRS and VRS measures of technical efficiency; this is as expected, since the three-input model includes an additional explanatory variable hence should capture more of the variation in efficiency. Nevertheless the difference between the two-input and three-input models is not always statistically significant.

Average VRS technical efficiency is much higher than average CRS technical efficiency; this results in strong evidence of scale inefficiency amongst students in most of the universities in the sample. There is some evidence that pre-1992 universities are more VRS-technical-efficient than post-1992 universities, whereas the difference in CRS technical efficiency between the two groups of universities is much smaller. The results also suggest that students in post-1992 universities may be more scale-efficient than in pre-1992 universities. As reported in Table 2, further analysis of the results indicates that decreasing returns to scale applies to students in most universities.[2]

Figure 1: Histograms of CRS and VRS efficiency relative to full sample.



Comparing the results of Panel A and Panel B of Table 2, going from applying DEA to all universities together, to DEA for pre-1992 and post-1992 universities separately, affects the results in specific ways. For pre-1992 universities, CRS technical efficiency is increased in both years for the three-input model, whereas VRS technical efficiency is almost unchanged.

[2] This is obtained by replacing the constraint $N1'\lambda = 1$ in the VRS model (2) with an inequality constraint $N1'\lambda \leq 1$; this yields the non-increasing returns to scale (NIRS) model. Comparing the NIRS technical efficiency score to the VRS technical efficiency score enables us to determine whether increasing returns to scale exist for that university.

On the other hand, for post-1992 universities, VRS technical efficiency is increased in both years for the two-input model, while CRS technical efficiency remains almost unchanged. In both cases this difference reflects the relative inefficiency of both groups of universities in these areas in the full sample.

Figure 1 shows the histograms of each of the four measures of efficiency for 2006 and 2007 where DEA has been applied to the full sample of universities. From this figure it can be seen that there is considerable variation in efficiency across universities, and that the efficiency distribution has changed between the two years. In all cases the distribution has shifted leftwards relative to the frontier in 2007; as confirmed by Table 2, relative student efficiency has decreased between the two years. Also, efficiency in the constant returns models is much more dispersed than in the variable returns models.

Figure 2: Histograms of VRS three-input efficiency relative to full sample.

2006 2007

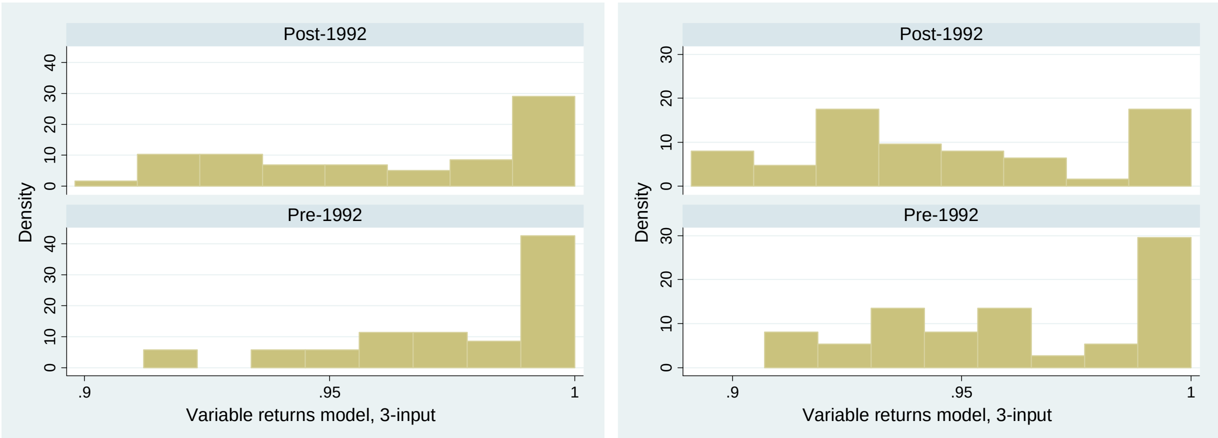


Figure 2 shows the histograms for VRS technical efficiency using the three-input all-universities model, dividing the sample into pre-1992 and post-1992 universities. From this figure it can be seen that, not only are the average levels of efficiency similar between the two groups of universities, there is also significant overlap in efficiency. Therefore, it is not possible to identify the type of university simply from the efficiency of its students.

5. Conclusions

This study estimated the efficiency of university students in England in producing degree results and satisfaction. Using a sample of 78 universities in 2006 and 2007, the results from DEA reveal that students have different levels of efficiency across universities. Pre-1992 and post-1992 universities exhibited differences in efficiency, with post-1992 universities having lower VRS technical efficiency.

The Report of the National Committee of Enquiry into Higher Education 1997 (also known as the Dearing Report) recommended amongst other things the rapid expansion of the UK university sector. Over the decade from 1996 to 2006 the total number of higher education students in the UK has increased from 1.75 million to 2.36 million, an increase of one-third, representing a participation rate in higher education of over 45 percent. With such a large percentage of the age-group in higher education it is perhaps unsurprising for such diversity in the efficiency of students to be found in this study. This diversity in student efficiency also suggests that heterogeneity in the organisation of university education might be more appropriate than the one-size-fits-all approach that currently prevails. Moreover, the results also indicate that there is sufficient overlap in the efficiency of pre-1992 and post-1992 universities such that the simple binary divide may be inappropriate for thinking about student efficiency.

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Appendix A: List of universities in the sample.

Pre-1992 Universities	Post-1992 Universities
Aston University	Bishop Grosseteste
University of Bath	Buckinghamshire Chilterns
University of Bradford	University of Chester
University of Bristol	Canterbury Christ Church
Brunel University	York St John University College
City University	Edge Hill University
University of Durham	University College Falmouth
University of East Anglia	University of Winchester
University of Essex	Liverpool Hope University
University of Exeter	University of Northampton
University of Hull	Newman College
Keele University	Roehampton University
University of Kent	Southampton Solent University
Lancaster University	University of Worcester
University of Leeds	Anglia Ruskin University
University of Leicester	Bath Spa University
University of Liverpool	University of Bolton
Goldsmiths College	Bournemouth University
Imperial College	University of Brighton
King's College	UCE
Queen Mary	University of Central Lancashire
SOAS	University of Gloucestershire
Loughborough University	Coventry University
University of Newcastle	University of Derby
University of Nottingham	University of Greenwich
University of Reading	University of Hertfordshire
University of Salford	University of Huddersfield
University of Sheffield	University of Lincoln
University of Southampton	Kingston University
University of Surrey	Leeds Metropolitan University
University of Sussex	Manchester Metropolitan University
University of York	Middlesex University
	De Montfort University
	Northumbria University
	Nottingham Trent University
	Oxford Brookes University
	University of Plymouth
	University of Portsmouth
	Sheffield Hallam University
	Staffordshire University
	University of Sunderland
	University of Teesside
	UWE
	University of Chichester
	University of Westminster
	University of Wolverhampton