smg space management group

UK HIGHER EDUCATION SPACE MANAGEMENT PROJECT

DRIVERS OF THE SIZE OF THE HE ESTATE

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Executive summary

1. This summary gives readers an overview of the work undertaken in developing a tool to benchmark the size of any higher education institution's (HEI's) estate in the UK.

2. The benchmarking tool is based on a statistically estimated relationship between the size of the non-residential estate and a number of drivers such as income, location, characteristics of the estate and composition of the student body. In our empirical work we used the 2004 Estate Management Statistics (EMS) report that provides data for 2002-03.

3. In addition to focusing on the size of the total non-residential estate, we also undertook a statistical analysis of the drivers of the size of core teaching space, specialist teaching space, general purpose teaching space, teaching offices, research space, libraries and learning resources centres and other support space.

4. A wide range of drivers were considered in our statistical analysis including income, an urban-rural location variable, space management methods such as space charging and centrally timetabling teaching space, the composition of the student body by student type and by subject, estate characteristics such as the average age of the buildings, their functional suitability and the number of sites.

5. Our key findings are the following:

- a higher income is strongly associated with having a larger estate. We estimate that having an additional £1 million of income is associated with having an estate 1,000 m^2 larger
- using central timetabling to allocate teaching space is associated with having a smaller estate. We find that even among HEIs with similar incomes and of comparable size, those that centrally timetable more space have considerably smaller estates. Thus there is substantial evidence that central timetabling helps economise on teaching space
- there is support for the view that space charging reduces space. We estimate effects of space charging that are consistently negative and often quite large, but are not always statistically significant. These estimated effects could perhaps be biased towards being too small, either because larger HEIs have adopted space charging or because HEIs that feel they have too much space have adopted this system
- we find fairly consistently that HEIs in more urban areas have smaller estates, all else being equal. The effect of local population density is typically negative, though it is not always statistically significant.

6. The benchmarking tool provided as part of the companion cost and benchmarking model is based on the statistical analysis described in this report.

Introduction

7. This report is one of several outputs from the first phase of the Space Management Project (SMP), co-ordinated by the UK-wide Space Management Group (SMG). The aim of the project is to provide useful tools to help higher education institutions (HEIs) to manage their space in an efficient and sustainable way that meets pedagogic, research and support needs.

8. Related outputs, which are all available on the SMG web-site, www.smg.ac.uk, are:

- 'Space Management Project: summary of phase one'
- 'Review of space management practice'
- 'The cost of space'
- a web-based spreadsheet model that allows HEIs to compute various cost estimates of their non-residential estate and to benchmark the size of their non-residential estate.

9. This report relates to the work on the benchmarking tool, focusing on the key drivers of the size of an HEI's non-residential estate, and how institutions can assess what size of estate is affordable.

10. Because this benchmarking tool is based on the average relationship between a set of space drivers and the actual size of the non-residential estate across the HE sector, its output will not provide an estimate of the best or most efficient size of the non-residential estate. Therefore, it should not be used in a normative manner, but rather the information provided by the benchmarking model can be one of many inputs in an institution's wider reflection on the appropriate size of its estate. There may be valid reasons why the non-residential estate of a particular HEI may deviate from the size that the benchmarking would predict.

The model – overview

11. The benchmarking tool essentially relates the size of an HEI's non-residential space to a number of drivers for the following space categories: total non-residential estate (on a net internal area basis), core teaching, specialist teaching, general purpose teaching, teaching offices, research, libraries/learning resources and other support.

12. In statistical terms, we estimated a relationship between space drivers and actual space as described in Equation 1.

Equation 1

Size of the estatej = f (external drivers Zi, space management variables Vi)

Where:

- 'Size of the estatej' is the size of the various types of higher education space as per SMP definitions
- 'Zi' are the external drivers
- 'Vi' are the space management variables.

13. Using a number of different data sources, we have estimated statistically the relationship between the space drivers and the actual space size that prevailed in 2002-03 as reported in the Estate Management Statistics (EMS) 2004 institutional report.

14. This estimated relationship reflects the average relationship between the size of the non-residential estate (or one of the other space categories) and a number of drivers, across all HEIs and can be used by HEIs for a number of different purposes:

a. **As a benchmarking tool.**

   An HEI can plug the values of drivers specific to itself into the estimated relationship, and generate an estimate of the size of estate that, on the basis of the relationship observed across all HEIs, would be consistent with these drivers. If the predicted size of the estate were significantly lower than the actual size, this would signal that either the HEI has excess space or that it needs all the space but faces a number of idiosyncratic factors that are not captured by the model. As with any benchmarking instrument, the user will need to reflect on the likely causes of the divergence from the typical relationship between estate size and drivers, and decide on the appropriate course of action.

b. **To predict changes in space.**

   This can be done by plugging into the estimated relationship a forecast of the drivers. For example, the estimated relationship can be used to generate a projection of the amount of space associated with a change in drivers, such as an increase in income, in the context of HEIs' current space performance.

c. **To reflect space charging and timetabling changes.**

   The estimated relationship can also be used to generate projections of changes in space requirements that would result from the introduction of space charging and increased use of central timetabling.

d. **To generate different estate planning scenarios.**

   Along the same lines, the estimated relationship can be used to generate a number of estate planning scenarios reflecting different drivers.

e. **With the cost spreadsheet of the web-based model to find the size of the sustainable estate.**

   Finally, this estimated relationship can be used with the cost spreadsheet to determine the size of the sustainable estate. The input into this analysis from the drivers model is the size of the estate that would be predicted by the estimated relationship, or judged as desirable by an HEI following a review of the reasons for any divergence between predicted and actual size.

The model – statistical analysis

15. In our statistical analysis, we examine many potential drivers of the size of estates, and pay particular attention to the effect of space management methods such as space charging and central timetabling.

Data on total space and sub-categories of space

16. Our data on non-residential estate sizes come from the 2004 EMS. From this we take the most recent data, which are for 2002-03. (See Table 1.)

17. Besides the main EMS data, the 2004 EMS also contain a supplementary table of SMG data, which includes data on HEIs' specialist teaching and research space and their library space. This was the first year that the EMS collected data on these sub-categories of space.

Table 1 **Space categories in drivers model**

Space category	EMS data source
Total non-residential estate	Main EMS, variable D12-C1 (total net internal non-residential space)
Core teaching	Main EMS, variable D12-C3
Specialist teaching	SMG data, variable S3a
General purpose teaching	Main EMS, variable D12-C3 (core teaching space) – SMG data variable S3a
Teaching offices	Main EMS, variable D12-C4
Research	Main EMS, variable D12-C5 (research offices) + D12-C6 (core research)
Libraries/Learning resources*	SMG data, variable S4 (library/learning space)
Other support	Main EMS, variable D12-C10 (total support space) – SMG data variable S4

* It was not possible to define an 'Administrative space' category, as the SMG had requested, because the EMS definition of 'Libraries/Learning resource centres' includes some of EMS variable D12-C8 (support offices), which the SMG had considered as 'Administrative space'. The 'Other support' category also differs from what the SMG had requested since it includes support offices that are not part of 'Student support space'.

Issues with some of the EMS space data

18. We have concerns about the consistency of some parts of the EMS data and, in particular, about the quality of the data on 'Specialist teaching space'. The EMS defines this to include laboratories, specialist theatres and drama studios, and other space that cannot easily be used for non-specialist activities. However, some HEIs define all their core teaching space as specialist teaching space. Some of these are generalist, not specialist HEIs. Other HEIs state that they have no specialist teaching space. These facts suggest that different definitions for specialist teaching space are being used across the sector.

19. Since we define 'General purpose teaching space' as core teaching space minus specialist teaching space, any variation in the definition of specialist teaching space would also reduce the reliability of our data on general purpose teaching space. Therefore, we also examine the drivers of core teaching space as defined in the main EMS.

20. The sample size of HEIs used in our statistical analysis is smaller than the number of HEIs in the EMS population because data are missing for some HEIs for some of the drivers.[1]

Table 2 **Summary statistics for space categories, m²**

Space category	Observations	Mean	Standard deviation	Minimum	Maximum
Total net internal non-residential	150	85,803	79,491	3,000	477,000
Core teaching	129	25,952	20,808	435	117,660
Specialist teaching	111	10,147	10,258	0	63,503
General purpose teaching	100	17,133	17,840	0	108,120
Teaching offices	129	9,226	8,112	77	44,520
Research	128	17,152	32,593	0	205,640
Library/learning resource centres	128	8,417	9,383	0	64,715
Other support	116	15,441	13,528	211	61,694
Miscellaneous	176	7,647	12,857	0	99,394

Estate size

21. Table 2 summarises the statistics for different categories of space. The dependent variable of most interest is (total) net internal non-residential area. This shows the mean net internal area across HEIs is 85,803 m^2 (based on EMS data for 2002-03), and that HEI estates differ greatly in size, from as small as 3,000 m^2 to as large as 477,000 m^2. Due to this great diversity, variables relating to institution size, such as income, explain much of the difference in estate size.

22. The large disparity in estate sizes across the HEIs also informed our choice of statistical model.

[1] We also drop two HEIs from the analysis. We drop one because the total non-residential space it reports exceeds the sum of the space it reported in the sub-categories of non-residential space (teaching, research, support, vacant and other). We also drop the Open University, as we are concerned that its small space relative to its income could confuse the regression results.

Choice of drivers

23. The initial list of potential drivers included the following:

- teaching income
- research income
- other income
- the percentage share of undergraduates in total student full-time equivalent (FTE)
- the ratio of student FTE to student headcount (reflecting the importance of part-time students)
- the ratio of students being taught to student FTE
- other student body characteristics
- the number of students (student FTEs)
- the number of FTE staff
- the ratio of teaching staff to total staff FTE
- the ratio of teaching and research staff to total staff FTE
- the ratio of support staff to total staff FTE
- the location of the HEI
- the average age of the buildings
- the number of non-residential buildings
- the number of sites
- whether the HEI is mainly a research university
- whether the HEI is a post-1992 or a pre-1992 university
- whether the HEI uses space charging
- the percentage of teaching space subject to central timetabling.

24. Following some preliminary analysis, we narrowed down the set of drivers to income drivers, student body characteristics, estate characteristics (functionality, number of sites, age, etc) and space management policy variables (eg, central timetabling and space charging).

Variables for the drivers

25. We use data on several types of drivers of estate size. For each type of driver the drivers model uses the following variables.

26. **Income.** We use HEIs' teaching, research and other income. We also construct the share of each HEI's total grant from its funding council (HEFCE, SHEFC or HEFCW) in 2004-05 that is a research grant. We use this share to test whether HEIs with large research functions have larger estates than those primarily focused on teaching.

27. **Urban-rural location.** To control for whether HEIs are in urban or rural areas, we use the population density in each HEI's local authority area.

28. **Space management methods.** The EMS survey asks: 'Does your HEI use space charging?' and 'What percentage of core teaching space is centrally timetabled?' We also use the EMS 'SMG data' on the dates when space charging and central timetabling were introduced.

29. **Student body by study type.** To control for the share of each HEI's student body that uses its campus very little, we use the percentage of each HEI's student FTEs that are sandwich, distance-learning and franchised student FTEs. To control for the share of part-time students, we use the share of student FTEs in the total student headcount. The larger the share of student FTEs in the total student body, the higher the percentage of students who study full-time, rather than part-time.

30. **Student body by subject.** To control for the subject distribution of student bodies, we use the share of students studying subjects in each of HEFCE's four price groups: A, B, C and D. HEIs receive more teaching grant for students in higher price groups (where A is higher than B).

31. **Estate type.** We use the share of the HEI non-residential estates in each of the four areas of functional suitability reported in EMS, the average age of each HEI's buildings and its number of sites.

32. A simple correlation analysis of these various drivers shows that the income variables are highly correlated (see Table 3). The number of sites also strongly correlates with income.

33. Central timetabling negatively correlates with the income variables, while space charging positively correlates with income. This implies that central timetabling tends to be used by smaller HEIs, and space charging by larger ones. Central timetabling and space charging negatively correlate with each other, confirming that using one method makes an HEI less likely to use the other.

Table 3 **Correlations between drivers**

	Teaching income	Research income	Other income	Research share	Population density	Space charging	Central timetabling	Average age
Research income	0.68							
Other income	0.76	0.89						
Research share	0.24	0.66	0.49					
Population density	-0.01	0.13	0.06	0.28				
Space charging	0.43	0.31	0.36	0.24	0.16			
Central timetabling	-0.49	-0.37	-0.37	-0.16	0.07	-0.24		
Average age	0.2	0.14	0.24	0.04	-0.22	0.13	-0.13	
Number of sites	0.05	0.16	0.1	-0.01	0.18	-0.18	-0.16	- 0.12

Source: London Economics

Statistical model of the space drivers

34. The statistical drivers model that underlies the benchmarking tool in the cost and benchmarking model on the SMG web-site takes account of the wide range of HEI estate sizes. It assumes some drivers will affect space in a linear fashion, whereas others will affect estate size in percentage terms.

35. We expect HEI income to increase the size of the estate in a roughly linear fashion. For example, teaching income is closely related to the number of students at an HEI. Therefore, every increase of £1 million in teaching income would correspond to roughly the same number of additional students, who would require roughly the same amount of additional space.

36. We expect the use of space charging to affect estate size in a percentage fashion. For example, HEIs that charge for space may eventually have estates 5 per cent smaller than if they had not started charging. The actual estate reduction in m^2 would differ according to an HEI's initial size. We assume that most other drivers, such as the share of students who are distance learners, would similarly affect the estate size in a percentage manner.

37. The precise formulation of the space drivers model is shown in Equation 2.

Equation 2: Formulation of the space drivers model

$$ESi = (a + b1\ INC\_Ti + b2INC\_Ri) \times (1+b3SCi) \times (1+b4CTi) + ei$$

Where:

ESi is estate size at the HEI 'i',

a is a constant term common to all HEIs,

INC_T is teaching income,

INC_R is research income,

SCi equals 0 if the HEI does not use space charging, and equals 1 if the HEI does do so,

CTi equals the percentage of core teaching space that the HEI subjects to central timetabling.

Thus, in Equation 2, teaching and research income affect estate size in a linear manner, while space charging and central timetabling affect estate size in percentage terms.

38. We estimate a number of variants of Equation 2 using non-linear least squares.

Summary of regression results

39. Table 4 shows the results of regressions of total net internal non-residential area on a limited range of drivers. This gives an overview of the determinants of estate size. Each cell reports a number (coefficient) that represents the change in estate size, in m^2, associated with an increase of the driver shown in the left-hand column by one unit.

40. Each coefficient is associated with a t-statistic, shown below it in brackets. A t-statistic greater than 2 (or less than -2) implies the coefficient is statistically significantly different from zero at the 5 per cent significance level.

Table 4 **Regression of total net internal space**

	1	2	3	4
Variables that affect space linearly				
Teaching income	**1,117**	**1,254**	**1,216**	**1,227**
	(15.6)	(13.4)	(12)	(9.6)
Research income	**1,117**	**1,060**	**1,042**	**877**
	(10.7)	(7.7)	(7.6)	(5.1)
Other income	**317**	**506**	**676**	**941**
	(1.3)	(1.5)	(1.9)	(2.2)
Variables that affect space in percentage terms				
Population density	**-0.003**	**-0.003**	**-0.002**	**-0.002**
	(-7.5)	(-5)	(-2.8)	(-2.6)
Space charging		**-0.12**	**-0.17**	**-0.13**
		(-4)	(-4)	(-4.3)
Space charging introduced before 2000 (dummy)			0.08 (1.3)	
Central timetabling		**-0.17**	**-0.21**	**-0.32**
		(-2.8)	(-3.3)	(-4.9)
Central timetabling introduced before 2000 (dummy)				0.03 (0.7)
R^2	0.97	0.98	0.98	0.98
N	150	119	111	88

Note: All regressions include constants. T-statistics are shown in brackets. Coefficients significant at the 5 per cent level are shown in bold. The variables of Columns 1-4 are described in paragraphs 25-31.

Source: London Economics

41. Column 1 of Table 4 shows that estate size has a strong positive relationship to income. An additional £1 million of teaching income is associated with an estate that is 1,117 m^2 larger. The relationship with research income is, by coincidence, exactly the same.

42. Column 1 also shows that estate size has a significant negative relationship with local population density. To put the coefficient of -0.003 into perspective, Brighton and Hove local authority has the mean population density in the sample, of around 30,000 people per hectare. An increase in population density by 10,000 people per hectare, to roughly the density of Luton, is associated with a decline in estate size of about 3 per cent.

43. Column 2 of Table 4 suggests that estate size is negatively related to whether HEIs use space charging. HEIs that charge for space have estates that are smaller than those that do not, by about 12 per cent. The effect of central timetabling is even larger: HEIs that centrally timetable all their core teaching space are estimated to have estates 17 per cent smaller than HEIs that do not centrally timetable any space. The large t-statistics associated with these coefficients imply that the negative relationships between total non-residential estate size and both space charging and central timetabling are highly statistically significant.

44. Column 3 tests whether HEIs that introduced space charging more than four years ago have smaller estates than those that did so more recently. This would be consistent with the assumption that space charging takes some time to have an effect. The coefficient on a longer history of space charging is in fact positive, and is not statistically significant. Thus, overall institutions that introduced space charging more than four years ago do not statistically have significantly less space than HEIs that introduced it more recently. While the effect on the actual size of the estate of such a space management tool may take some time to materialise, the four-year cut-off used in our analysis may be too crude a threshold to capture the dynamics.

45. Column 4 of Table 4 tests whether HEIs that introduced central timetabling more than four years ago have smaller estates. Again this would be consistent with the theory that the effect of central timetabling evolves slowly. As in the case of the space-charging variable, the coefficient on a longer history of central timetabling is positive, but is not statistically significant.

The model and clustering

46. The philosophy underlying our approach is that, even though the model is estimated across all HEIs, if a limited number of institutions face a specific driver that is only common to them, the model should allow for this by explicitly including this driver.

47. In other words, if in practice HEIs are clustered or thought to be clustered, the factors (or drivers) underlying these clusters are explicitly taken into account in the model – provided they are included in the long list of drivers described above. This list of drivers was discussed a number of times with HEFCE staff and at SMG meetings, and incorporates suggestions from both groups.

48. Examples of drivers that may explain a certain form of clustering among HEIs are the share of research income in total grant income, or whether or not they belong to the Russell Group or the Group of 1994.

49. By including such variables in the model we were able to test empirically whether research-orientated HEIs are different from other HEIs in their space holdings, after the effect of different levels of research income has been taken into account. In this case, the variable proxying for the research focus of an HEI was never statistically significant. In other words, the level of research income alone was found to explain statistically the space differences between research and non-research HEIs.

50. This modelling approach was used separately for each of the space categories listed earlier. Because the data availability varies across the various space categories, the size of the sample of HEIs over which the model for each space category is estimated also varies. A group of 89 HEIs provide information on the size of their general purpose teaching space. The same HEIs plus five others provide information on the size of their specialist teaching space. The latter group of 94 HEIs grows to 104 in the case of core teaching space, teaching offices and library/learning resource centre space; and to 105 in the case of research space. Finally, the sample, over which the model for the total non-residential estate was estimated included six additional HEIs, giving a total of 111.

51. One way to check whether some specific clusters of HEIs have been overlooked in the model is to examine whether the model systematically over-predicts or under-predicts the size of the estate for certain groups of HEIs.

52. This examination focuses on the percentage difference between the model's space prediction and the actual space for the following clusters of HEIs:

- Russell Group
- pre-1992 HEIs not in the Russell Group
- post-1992 universities
- small specialised HEIs
- other.

53. In Table 5 we report, for each group of HEIs, the average percentage difference between the predicted and actual size of the non-residential estate, and the largest and smallest difference. We also report the number of positive differences (where the predicted size of the non-residential estate is larger than the actual size) and negative differences (where the predicted size of the non-residential estate is smaller than the actual size) in each group.

Table 5 **Percentage difference between predicted and actual non-residential estate**

	Average percentage difference*	Largest positive percentage difference	Largest negative percentage difference	Number of positive differences	Number of negative differences
Russell Group	0.09	0.26	-0.11	10	7
Pre-1992 non Russell Group	0.01	0.32	-0.36	12	19
Post-1992 universities	0.04	0.29	-0.21	22	12
Small, specialised institutions	-0.11	0.55	-0.47	4	9
Other	-0.17	0.14	-0.41	4	19

* Predicted minus actual as a percentage of actual.

54. In the case of the first three groups, the average percentage difference between predicted and actual space is small and there does not appear to be a systematic clustering of the differences in either the positive or the negative space. Because of missing data in EMS, the number of small, specialised institutions for which we could generate space predictions is too small to be able to draw any firm conclusion about a possible bias.

55. Finally, the last category, 'other' shows a bias towards predicting a smaller size of the non-residential estate than the actual size. However, because this category regroups a wide a range of different institutions, it is not possible to draw any firm conclusions about an omitted cluster factor in the model.

Models of the different space categories

56. We also examine the drivers of the amount of various sub-categories of space across HEIs. Again we estimate statistical models of the form shown in Equation 2. Table 6 shows the results of these regressions.

Table 6 **Regressions of sub-categories of space**

	1 Specialist teaching	**2** General purpose teaching	**3** Core teaching	**4** Teaching offices	**5** Research	**6** Library/ Learning resource	**7** Other support
Variables that affect space linearly							
Teaching income	**201**	**255**	**488**	**184**	-36	**86**	**298**
	(4.4)	(5)	(8.9)	(8.7)	(-1)	(3.2)	(8.5)
Research income	**-147**	**225**	37	-31.5	**766**	**145**	28
	(-2.7)	(3)	(0.5)	(-1.2)	(11.9)	(3.8)	(0.6)
Other income	86	15.6	119	138	243	146	26
	(0.6)	(0.1)	(0.6)	(2)	(1.6)	(1.6)	(0.2)
Variables that affect space in percentage terms							
Population density	0.00	-0.002	-0.001	**-0.003**	**-0.002**	**-0.008**	-0.002
	(0.02)	(-1)	(-1.2)	(-2.7)	(-2)	(-8.5)	(-1.7)
Space charging	0.05	**-0.21**	**-0.12**	-0.04	**-0.16**	0.01	-0.05
	(0.4)	(-3)	(-2.3)	(-0.5)	(-3.8)	(0.1)	(-0.6)
Central timetabling	**-0.57**	**-0.48**	**-0.51**				
	(-4.4)	(-3.5)	(-6.3)				
R^2	0.76	0.89	0.93	0.89	0.95	0.86	0.89
N	94	89	104	104	105	104	99

Note: All regressions include constants. T-statistics are shown in brackets. Coefficients significant at the 5 per cent level are shown in bold. The variables in Columns 1-7 are described in paragraphs 25-31.

Source: London Economics

57. The sample sizes in Table 6 are smaller than those in Table 4 because of missing data.

58. Column 1 in Table 6 shows that higher teaching income is associated with greater specialist teaching space. Greater research income is associated with less specialist teaching space. This result is slightly counter intuitive: we might expect greater research income to have no effect on specialist teaching space. We do not read very much into this result, since we suspect the data on specialist teaching space are somewhat unreliable. Column 1 also shows that central timetabling is associated with less specialist teaching space. There is no significant relationship with space charging.

59. Column 2 of Table 6 shows that both greater teaching income and greater research income are associated with an HEI having significantly more general purpose teaching space. It is hard to see why research income would affect specialist and general purpose teaching space differently. This result may again be driven by the use of different definitions of 'specialist teaching space' across HEIs. General purpose teaching space is strongly negatively correlated to HEI use of both space charging and central timetabling.

60. Column 3 of Table 6 examines the drivers of core teaching space, probably a more consistently defined category of space than specialist or general purpose teaching space. This column shows that having an additional £1 million in teaching income is associated with having almost 500 m^2 of additional core teaching space. There is no significant relationship with larger research income. This is an intuitively reasonable result. Space charging is estimated to reduce core teaching space by 12 per cent, which seems at the high end of expectations, and central timetabling to reduce core teaching space by 51 per cent. This effect on core teaching space is probably overly large. It might suggest that smaller HEIs are more likely to centrally timetable space, so that central timetabling is an endogenous variable. This would imply that the estimated effect of central timetabling is biased towards finding a larger negative effect. Despite this possibility, the regressions presented here suggest that central timetabling is likely to have a negative effect on teaching space.

61. Columns 4 to 7 examine the drivers of teaching office space, research, library and other support space. The model estimated for these categories of space omits central timetabling, since this is only used to allocate core teaching space. The effects of income on space are intuitively plausible: teaching income affects teaching office, library/learning resources and other support space but not research space. Research income affects research space and library/learning resource space, but not teaching office or other support space. Space charging has a negative and statistically significant relationship with research space but no statistically significant relationship with other types of space.

62. Table 6 overall gives support to the theory that HEI space is negatively related to the use of space charging. The estimated effects of space charging on the amount of space are typically negative, but are statistically significant only in the case of core teaching and research space. However, the evidence from Table 4, which showed a significant negative effect of space charging, is probably more reliable. This is because total space is probably defined more consistently across HEIs than some of the sub-categories of space, and because the sample sizes in Table 4 are generally larger.

63. Looking across all the columns in Table 6, we see a relationship with the population density of the HEI's local authority area that is typically negative, but statistically significant only for some categories of space, in particular library/learning resource space. Thus, these results give some support to the results of Table 4 that there is a negative relationship between total space and local population density.

Results of detailed regressions

64. Table 7 shows regressions of total and core teaching area on a more extensive list of drivers. Including more drivers tends to reduce the sample size because for each driver some HEIs are missing data, and must therefore be excluded from the regression.

65. In Column 1 of Table 7, the income variables again have positive and statistically significant effects.

66. Use of space charging is associated with having an estate that is 12 per cent smaller. This coefficient is statistically significant, suggesting that space charging does affect estate size if we control for all other drivers of estate size. Thus, considering all the regressions in Tables 4, 5 and 7, there is fairly consistent evidence that space charging reduces estate size.

67. Again Column 1 of Table 7 finds a statistically significant coefficient on central timetabling: HEIs that centrally timetable all their core teaching space have estates 29 per cent smaller than those that centrally timetable no space.

68. Column 1 also finds that HEIs with a greater share of students in price band B have significantly larger estates. The coefficient implies that an HEI with all its students in band B would have 53 per cent more space than an HEI with none. This result is rather hard to interpret, since there is no apparent effect of having more students in bands A or C. There is no evidence that having a greater share of space in poor condition (in grade C or D) has a positive effect on the size of the estate. If this effect existed, the coefficients on space in grades A and B would be negative.

69. None of the other drivers in Column 1 has a statistically significant effect.

70. Column 2 of Table 7, the regression of core teaching space, gives much the same results as those in Tables 4 and 5. Greater teaching income is associated with more teaching space, while space charging and central timetabling are associated with having less teaching space.

Table 7 **Results of detailed regressions of estate size**

	1 Total area	**2** Core teaching area
Variables that affect space linearly		
Teaching income	**519** (2.3)	170 (1.4)
Research income	392 (1.7)	5 (0.1)
Other income	**732** (2.1)	159 (1.2)
Variables that affect space in percentage terms		
Share of research funding in total grant	-0.21 (-0.7)	-0.23 (-0.4)
Population density	-0.001 (-1.2)	-0.001 (-1)
Space charging	**-0.12** (-3.7)	**-0.14** (-2.4)
Central timetabling	**-0.29** (-5.5)	**-0.43** (-4.8)
Share of space by functional suitability		
Grade A	0.25 (0.9)	-0.57 (-0.5)
Grade B	0.76 (1.7)	**-1.6** (-2.5)
Grade C	0.4 (1)	-2.76 (-1.7)
Shares of student body by study type		
Sandwich students	-0.34 (-0.3)	-0.29 (-1.2)
Distance-learning students	-0.73 (-1.1)	-0.45 (-0.6)
Franchised students	**-1.23** (-2.7)	1.4 (1.6)
Student FTEs as share of student headcount	0.22 (0.7)	3.2 (2)
Shares of student body by subject		
Subjects in price group A	-0.25 (-0.6)	-0.21 (-0.6)
Subjects in price group B	**0.53** (2.1)	0.94 (1.1)
Subjects in price group C	0.4 (1.7)	-0.04 (-0.1)
Average age of buildings	0.001 (0.8)	0.004 (1.3)
Number of sites	-0.01 (-2.6)	-0.01 (-1.5)
R^2	0.99	0.96
N	96	86

Note: All regressions include constants. T-statistics are shown in brackets. Coefficients significant at the 5 per cent level are shown in bold. The variables in Columns 1 and 2 are described in paragraphs 25-31.

Source: London Economics

Summary

71. Four general results stand out from the regressions in Tables 4, 5 and 7.

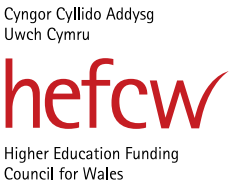
a. Having more income is strongly associated with having a larger estate. We estimate that having an additional £1 million of income is associated with having an estate 1,000 m^2 larger.

b. Using central timetabling to allocate teaching space is associated with having a smaller estate. We find that even among HEIs with the same income and of comparable size, those that centrally timetable more space have considerably smaller estates. Thus there is substantial evidence that central timetabling helps economise on teaching space.

c. There is support for the view that space charging reduces space. We estimate effects of space charging that are consistently negative and often quite large, but are not always statistically significant. These estimated effects could perhaps be biased towards being too small, either because larger HEIs have adopted space charging or because HEIs that feel they have too much space have adopted this system.

d. We find fairly consistently that HEIs in more urban areas have smaller estates, all else being equal. The effect of local population density is typically negative, though it is not always significant.

72. We recommend users to compare their own HEI to the average relationship between drivers and space using the benchmarking tool that forms part of the model on the web-site. Because the benchmarking tool is a general one, it omits any idiosyncratic factors that could affect the estate size of some HEIs. So in undertaking their benchmarking exercise, HEIs should take account of any such special factors.



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