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Carlos Cortinhas*

Abstract

The arguments for and against lecture capture have been going for some time and the debate is far from being settled definitely either way. Most of the existing research about the impact of lecture capture on student attainment seems to show negligible or little effects while examples of a negative relationship between lecture capture and learning outcomes abound.

The main purpose of this study is to add to the existing literature by conducting a large scale investigation (involving more than 2400 students in 26 modules offered by the economics department of a major British university) on whether lecture capture improves student performance. A secondary objective is to determine whether some groups of students use lecture capture more than others and whether lecture capture can lead to differing benefits for students in different types of subjects.

The data shows, in line with previous studies, that certain groups of students use lecture recordings significantly more than their peers (e.g. female students, international students, students from a low socio-economic background and ethnic minorities). Other results were unexpected. Notably, disabled students (including the sub-group of dyslexic students) and mature students were found not to not use lecture recordings more than others. Also, students taking quantitative modules and students doing economics majors were found to use lecture recordings significantly less.

The regression analysis showed that lecture recordings yielded (at most) a small positive effect on student performance.

Keywords: lecture capture, patterns of usage of lecture capture, online education.

JEL Codes:

1. Introduction

The adoption of lecture capture as a means of e-learning has increased rapidly worldwide in the higher education sector and this trend is also naturally present within the United Kingdom (UK). This technology is now offered by most, if not all UK universities, in some form or another[1].

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[1] Although most universities seem to be adopting the most comprehensive, centrally supplied software like Panopto and Echo360, most universities are using to a wide variety of less automated, less comprehensive (and sometimes free) technology solutions like Matterhorn, Camtasia Relay, MediaSite and Jing.

Generally speaking both students and universities seem to be strongly in favour of the use of lecture recordings but among academics there seems to be no consensus yet[2].

Students are strongly in favour of lecture recordings as believe it helps them improve their exam performance (see for example David et all (2011)) even when the evidence points the other way (Franklin et all (2011)). Most students, seem to view lecture recordings as a supplement not a substitute to attending lectures (Taplin et all (2011)) and seem to use lecture recordings mostly for revision purposes and to support note-taking[3].

Similarly, most Universities are also strongly in favour as lecture recordings as it is seen as increasing student satisfaction (Owston et all (2011)), improving cost efficiency to meet tighter fiscal constraints (Bosshart and Chiang (2016)) and meet regulatory requirements with respect to students with disability[4].

Among academics the picture is more mixed with academics strongly placed on both sides of the argument. The lack of consensus about the use of this technology might be linked with the conflicting evidence to date of the impact of lecture capture on face-to-face class attendance, student performance and student behaviour. On attendance, several studies report that lecture recordings lead to a significant drop in attendance and some even report that a significant proportion of students stop attending lectures entirely (e.g. Owston, Lupshenyuk and Wideman (2011)) whilst many other studies, report little or no significant drop in attendance (e.g. von Konsky, Ivins and Gribble (2009)). This lack of consensus also transpires in terms of the effects of lecture recordings on student performance. While some studies seem to report little or no effect (e.g. Franklin et all (2011), Bosshardt and Chiang (2015)) others report significant positive effects (e.g. Terry et all (2015), Traphagan, Kucsera and Kishi (2010)). Another area of concern among academics is the way students use this resource. Some worry that lecture recordings facilitate procrastination by enabling students to 'binge study' by delaying more of their study until immediately prior to exams (Chai, 2014). Another strand, exemplified by Williams, Birch and Hancock (2011) for example, show that lecture recordings are only effective in improving student performance when used as a complement to lectures

[2] For recent surveys of the literature on the pros and cons of lecture capture see for example Owston, Lupshenyuk and Wideman (2011), Bosshardt and Chiang (2016) or Terry et all (2015).
[3] See for example Elliot and Neal (2016) for a survey of the reported uses of lecture recordings by students.
[4] Many universities in the UK are using lecture recordings as a toll to support the Universities' implementation of the Equality Act (2010) and meet its statutory duty to provide anticipatory reasonable adjustments following changes to the provision to disabled students.

whilst if allowed to be used as a substitute, it provides no additional benefit and can in fact be detrimental to a student's performance[5]. Finally, some studies (e.g. Wielding and Hofman (2010)) find that students who attend fewer lectures have more benefits from viewing online lectures than students who attended many lectures, suggesting that overreliance on this resource, as opposed to more traditional learning, might be detrimental to students[6].

Many studies suggest that lecture recordings are of particular importance to certain groups of students, including international (non-native language speakers) students, students with disabilities (especially students with dyspraxia and dyslexia) (e.g. Leadbeater et all (2013)) and low achieving students (e.g. Owston, Lupshenyuk and Wideman (2011)).

Although difficult to summarize given the extent of the literature on the subject, the key findings of the literature seem to be as follows.

Students and universities are strongly in favour of lecture recordings whilst academics are yet to agree on whether it is beneficial to learning and teaching. Specific groups of students use this resource more intensively (international students, disabled students, low achievement students) than others. To date, the link between the viewing of lecture recordings and student achievement is not entirely clear. Some studies show positive effects while others showed no or negligible effects. The existence of lecture recordings seems to lead to lower attendance. The benefits of lecture recording when they exist, are associated with its use as a complement not substitute to attending face-to-face lectures but lower attendance that does not always seems to matter for student performance (Traphagan, Kucsera and Kishi (2010)).

This paper attempts to add to the existing literature by focusing on data from a large scale experiment to establish patterns of usage of lecture recordings in a UK context and to attempt to determine whether lecture recordings helps students to improve their attainment.

[5] It is worth noting that this finding is far from universal with many studies finding evidence to the contrary (e.g. Traphagan, Kucsera and Kishi (2010)).
[6] Wieling and Hofman (2010) study was based on students of Law and International Relations and International Organization not Economics students.

2. Data

The data for this study is composed of all students registered to take at least an economics module (either at undergraduate (UG) or postgraduate level (PGT)) in term 1 (autumn term) of the 2016/17 academic year at the University of Exeter in the United Kingdom.

One of the motivations for this study is that since September of 2016 a new lecture capture policy was implemented at Exeter University whereby the lectures of all modules were automatically recorded and made available to students as long as the technology was available in the teaching room[7]. Although lecture recordings have been available for many years, this new policy increased the number of lecture recordings available to students substantially and a natural question to raise is whether this increase in resources made available to students yielded any positive results to their performance.

The dataset is comprised of data on 24 undergraduate modules and 6 postgraduate modules, totalling 5,232 observations from 2,421 students[8]. This includes not only students doing a major or minor in Economics but also many students from other subjects (e.g. geography, language students) that are taking one or more modules of economics as an elective.

The data for this study includes data on student performance (final mark), time spent watching lecture recordings during the term[9] (in hours), student evaluation of the teaching[10], data on the characteristics of each module the student takes (whether the module is quantitative, whether the module is assessed 100% by a final exam, among others) and data on a large number of student observable traits, including age (at the end of the academic year), gender, ethnicity, country of domicile, undergraduate degree, whether the student has a disability, whether the student came from a state-funded or private-funded independent school and whether the student took an A-level in Maths and/or Economics at high school[11].

[7] Only the larger lecture theatres were equipped with the lecture capture functionality so that not all lectures could be recorded. It is also worth noting that academics are allowed to opt-out from this policy without having to provide a reason.
[8] The implication is that on average each student took on average 2.2 economics modules during the period of analysis. Data on lecture recordings was only available on 26 modules (22 UG plus 4 PGT).
[9] The lecture capture technology used at Exeter University is Panopto. This technology is set up centrally and automatically collates information on the number of views per student and per module and the length of time in seconds of each viewing (this amount was converted to hours in this study).
[10] The teaching evaluation consists of the result of student evaluations (Likert scale from 1-low to 5-high) on the question 'Overall I am satisfied with the quality of the module.
[11] The A-level is a high school qualification offered to students completing secondary or pre-university education. Students are required to study at least 3 A-levels (or equivalent) in order to be accepted to study for an undergraduate degree. The number of nationalities in the sample is 95.

An immediate interesting fact, is that about 50% of students in the sample (1,213 students corresponding to 1,877 observations) did not access any lecture recordings during the whole term. Also, interesting is that the average final mark of students that did not access any recordings (61.97%) was significantly lower than the average mark of the group of students that had some access to lecture recordings (64.56%)[12]. Although no causality can be established, it is interesting that this difference is very close to the 3% difference reported by Terry et all (2015) for students completing business courses in an USA context.

Table 1 presents the summary statistics of the main data used in this study.

Table 1: Sample Statistics of Key Variables

Variables	Observations	Mean	Standard Deviation
Final Mark	5,232	63.632	14.550
Lecture Capture (hours)	3,355	3.006	4.740
Lecture Capture (views)	3,347	13.616	19.310
Module information			
Teaching Evaluation	5,232	3.729	0.790
Assessment: Final Exam = 100% of final mark	5,232	0.214	0.410
Assessment: Final Exam ≥ 70% of final mark	5,232	0.893	0.310
Personal data			
Maths A-level	5,232	0.725	0.446
Economics. A-Level	5,232	0.704	0.457
Gender (male=1)	5,232	0.640	0.481
Disabled student	5,210	0.076	0.265
State School	4,933	0.660	0.474
Age	5,232	20.376	1.786
Low socio-economic class	2,836	0.130	0.337
Low participation neighbourhood[13]	5,232	0.059	0.235
Fee Status: International	5,232	0.252	0.434
Ethnicity			
White	5,232	0.680	0.473
Chinese	5,232	0.091	0.287
Indian	5,232	0.033	0.180
Black	5,232	0.023	0.150
Pakistani	5,232	0.003	0.050
Mixed	5,232	0.022	0.148
Other	5,232	0.047	0.212
Programme of study			
UG Economics Major	5,232	0.492	0.500
UG Economics Minor	5,232	0.198	0.399
UG Accounting programmes	5,232	0.046	0.209
UG Management programmes	5,232	0.083	0.276
PGT Economics Major	5,232	0.013	0.113
PGT Economics Minor	5,232	0.022	0.147
Other	5,232	0.145	0.352
Country/Region of domicile			
England	5,232	0.609	0.488
China	5,232	0.063	0.243
Wales	5,232	0.249	0.156
Hong Kong	5,232	0.036	0.186
France	5,232	0.018	0.131
India	5,232	0.018	0.131
Singapore	5,232	0.017	0.130

[12] This difference was significant at 1% level when conducting a two-sample t test (t-value = 6.20).

[13] Students from neighbourhoods with low participation in higher education are defined as UK students coming from POLAR 3 quintiles 1 and 2 (the postcode areas with the lowest rates of progression to HE, representing the 40% of school leavers least likely to progress to HE). More information on the participation of local areas (POLAR) classification and how it is used in the UK to support widening participation activities can be found at the Higher Education Funding Council for England (HEFCE) website.

Table 1 provides some interesting facts. Firstly, the average use of lecture recordings is very small when you compared it with the total amount of available lecture recordings (the average amount of lecture recordings available to students is about 21 hours per term). Secondly, the average number of views is about one per teaching week. The sample is mostly composed by male students (64%), of white ethnicity (68%) and from England (60.9%). About 50% are doing an economics undergraduate major, 20% an undergraduate economics minor and 3.5% are doing a postgraduate major or minor in economics.

Next, we turn to investigate differences in patterns of lecture capture viewing among different groups. This is an important issue as the existing literature seems to suggest that lecture capture is of particular use for certain groups of students (e.g. international students, disabled students, low achieving students, among others). Table 2 presents the mean values and the t test statistic for two independent samples for a selection of variables.

Table 2: Patterns of Lecture Capture use (in hours per term) in Selected Variables

Variables	Yes (Mean)	No (Mean)	t statistic
Gender (Male)	2.669	3.558	5.292***
Disable (all)	2.998	3.104	-0.350
Disable (dyslexia, dyspraxia or ADHD only)	3.103	3.001	-0.254
Mature	3.090	3.002	-0.236
International Student	3.454	2.860	-3.133***
State School	3.097	2.849	-1.459
Low participation neighbourhood	3.284	2.988	-0.863
Quantitative module	1.709	3.206	6.259***
Module assessed solely by final exam	4.490	2.689	-8.473***
Maths A-level	2.925	3.033	-0.571
Economics. A-Level	3.035	2.934	-0.557
Low socio-economic class	3.555	2.962	-1.899*
Ethnic minority	3.316	2.911	-2.095**
Programme of study			
Undergraduate (UG) - All	3.061	1.660	-2.795***
UG Economics Major	2.811	3.223	2.513***
UG Economics Minor	3.688	2.833	-4.207***
UG Accounting programmes	2.648	3.022	0.921
UG Management programmes	1.994	3.060	2.846
PGT Economics Major	0.303	3.033	3.297***
PGT Economics Minor	1.290	3.044	6.209***
Other	5,232	0.145	0.352
Country/Region of domicile			
England	2.875	3.221	2.052**
China	3.015	3.006	-0.027
Wales	3.913	2.983	-1.786*
Hong Kong	3.325	2.996	-0.714
France	2.806	3.009	0.299
India	4.428	2.981	-2.325**
Singapore	2.858	3.009	0.253

*** p<0.01, ** p<0.05, * p<0.10
(p-values for a two-tailed T test)

Table 2 shows statistically significant differences among a number of variables. Some of the differences are expected and are generally in line with previous studies: international students use more lecture recordings than Home/EU students[14] as do students from a low socio-economic class or from an ethnic minority.

There are also, however, some surprising results. Economics students, either taking a major undergraduate or postgraduate degree in Economics, use lecture recordings less than students from other programs taking economics modules, even those doing an UG economic minor. Also, students enrolled in quantitative modules use a lot less lecture recordings than their peers is more discursive modules. One possible explanation for the latter two findings is that students in technical subjects like economics require more face-to-face and regular study so that students that use primarily online lectures in their studies may be less motivated than their peers and may be using recordings to replace attendance to face-to-face lectures leading to lower attainment[15].

Furthermore, the data shows no difference in viewing patterns for disabled students, even when the sub-group of students with dyslexia/dyspraxia/ADHD is considered and this results contrast with results from previous studies (e.g. Leadbeater et all (2013)). Finally, students on modules that are assessed solely by one final exam tend to watch lecture recordings more than their counterparts. Although we cannot establish this here, one reason might be the procrastination behaviour identified by Chai, 2014 whereby by having access to lecture recordings, students delay more of their study until immediately prior to exams.

Another interesting finding is that the correlation between the length of lecture recordings viewed and the quality of teaching in each module was found to be 0.270 (significant at 1% level) which clearly suggests that the relationship between quality of teaching and amount of lecture recordings viewed to be positive and that students do not seem to be replacing attending lectures of poorer quality with watching lecture recordings instead. In fact, the better the quality of teaching, the more the students assess lecture recordings[16].

[14] In the UK, for the time being British and European Union students are treated the same in terms of fee status. International students are students from outside the EU.

[15] Inglis et al. (2011) in a study of another technical area of study, engineering and maths, found students who preferred online classes to attain lower marks than those that used face-to-face lectures.

[16] A similar correlation coefficient (0.255) exists between final mark and the number of views of lecture recordings.

3. Empirical Methodology

We assume that the impact of lecture capture viewing on the final mark (M) of pupil *i* on subject *j* can be explained by the following simple education production function:

$$M_{ij} = \beta LC_{ij} + \delta x'_{ij} + \varepsilon_{ij} \quad (1)$$

Where M_{ij} is the final mark for student i on module j, LC_{ij} is the sum of viewing of lecture capture (in hours per term) by student i on module j, x'_i is a vector of observed student traits (including Nationality, Age, Gender, Degree, whether the student has an A-level in Maths and/or Economics, Ethnicity, etc.) and of module characteristics (including quality of teaching, whether the module is quantitative, whether the module is assessed solely with a single final exam, among others) and ε_{ij} is a zero mean, normally distributed error term.

4. Results

Table 3 presents of the results of the baseline model, in five alternative regressions with alternative combinations of the vector x'_i variables[17]. Given that the number of observations per student varies from 1 to 4 (i.e. each student took at least one but up to 4 modules during the term), module dummies were included in all five specifications.

Two results immediately stand out. First, the coefficient for lecture recording yields the expected sign and is highly significant in all specifications (1% level). The coefficient varied from 0.10 to 0.15, suggesting that watching lecture recordings is a positive determinant of academic performance, albeit a very small one. Secondly, the coefficient of determination, R-square, is at best 0.21 suggesting that most of the variation observed in the final mark variable is not accounted for in this model suggesting some important determinants of academic performance are missing and we may have an omitted variable problem (this will be discussed in section 6 below).

[17] Some combination of control variables (e.g. age and mature, low socio-economic class and low participation neighbourhoods, etc.) were avoided to prevent collinearity.

Table 3: OLS Regression Results baseline model

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Final Mark	Final Mark	Final Mark	Final Mark	Final Mark
Lecture Recordings	0.0969**	0.1328***	0.1170**	0.1465***	0.1384***
	(0.0477)	(0.0465)	(0.0481)	(0.0467)	(0.0463)
Constant	63.4855***	324.0630	260.8865	83.6620***	274.7091
	(4.3713)	(339.0764)	(241.3199)	(5.9724)	(252.0708)
Observations	3,355	3,355	3,355	3,355	3,355
R-squared	0.183	0.209	0.199	0.213	0.212
RMSE	12.66	12.47	12.55	12.44	12.45
LogLikelihood	-13263	-13209	-13230	-13201	-13203
Controls:					
Module dummies	Y	Y	Y	Y	Y
Module related	N	Y	Y	N	Y
Teaching Quality	N	N	Y	Y	N
Maths A Level	N	Y	N	N	Y
Econ A Level	N	Y	Y	Y	Y
Quantitative Module	N	Y	N	Y	Y
Level: Undergraduate	N	N	Y	N	Y
Assessed solely by final exam					
Student related	N	N	Y	Y	N
Age	N	Y	N	N	Y
Mature	N	Y	Y	N	Y
Gender	N	N	N	Y	Y
Ethnic Minority	N	N	Y	N	Y
Disability	N	Y	Y	N	Y
State School	N	Y	N	Y	Y
Fee status: International	N	N	Y	Y	N
Low socio-economic class	N	Y	N	N	Y
Low participation Neighbourhood					

Heteroscedasticity-robust standard errors in parentheses, clustered by student
*** p<0.01, ** p<0.05, *** p<0.10

Because the sample is fairly large we can also run a separate regression for the students who performed well (i.e., achieved at final mark of at least 40%[18]) and students who didn't. Table 4 presents the same 5 specifications as Table 3 but uses as the sample only the students that performed well.

The results are clearly generally in line with those in Table 3, with the major difference being the size of the coefficient for the variable Lecture Recording that drops in all specifications going from a range between 0.10 and 0.15 to a range between 0.08 and 0.12. Importantly, the coefficient for Lecture Recordings remains significant at the 1% level in all but one specification (where it drops to 5%) and positive in all five specifications.

[18] The pass mark for UG modules is 40% and for PGT modules is 50%. The 40% threshold as a definition of success was used for both UG and PGT for consistency.

Table 4: Regression Results with sample of students that passed the module

VARIABLES	(1) Final mark	(2) Final mark	(3) Final mark	(4) Final mark	(5) Final mark
Lecture Recordings	0.0812**	0.1085***	0.0966**	0.1228***	0.1104***
	(0.0412)	(0.0401)	(0.0417)	(0.0405)	(0.0400)
Constant	70.9266***	-366.4051	-431.8612	83.8592***	-374.6571
	(4.2988)	(627.0234)	(599.8885)	(4.5029)	(636.3017)
Observations	3,213	3,213	3,213	3,213	3,213
R-squared	0.217	0.243	0.230	0.241	0.244
RMSE	10.39	10.23	10.32	10.24	10.23
LogLikelihood	-12068	-12014	-12041	-12017	-12011

Robust standard errors in parentheses, clustered by student
*** p<0.01, ** p<0.05, * p<0.1
Control variables not shown

Similarly, Table 5 presents the results for the remaining students, i.e. only students that failed (i.e., students who did not achieve a mark of 40%).

The results show that for the sample of students that failed the module, the coefficient for homework grade becomes statistically insignificant in all specifications. Although interpretation must be cautious given the small number of observations, the results seem to suggest that low performing students do not benefit from lecture recordings which is contrary to their better performing counterparts and this contradicts the results reported by Owston, Lupshenyuk and Wideman (2011).

Table 5: Regression Results with sample of students that failed the module

VARIABLES	(1) Final mark	(2) Final mark	(3) Final mark	(4) Final mark	(5) Final mark
Lecture Recordings	-0.3281	-0.3124	-0.3107	-0.3277	-0.3181
	(0.3108)	(0.3062)	(0.3081)	(0.3182)	(0.2883)
Constant	12.0031***	-784.9549**	-960.9243***	-12.6685	-827.7720**
	(0.0030)	(311.5500)	(332.5659)	(13.3932)	(348.7467)
Observations	142	142	142	142	142
R-squared	0.390	0.420	0.473	0.432	0.438
RMSE	8.659	8.709	8.302	8.542	8.651
LogLikelihood	-494.9	-491.3	-484.6	-489.9	-489.1

Robust standard errors in parentheses, clustered by student
*** p<0.01, ** p<0.05, * p<0.1
Control variables not shown

5. Addressing the '*Elephants in the Room*'

The first 'elephant in room' is that the main variable of interest (lecture recordings viewed in hours) is likely to be correlated with (unobserved) student's personality traits, cognitive ability and other factors that determine effort, motivation and performance.

If we ignore the vectors with control variables and assume that the "true" model is given by

$$M_i = \beta LC_i + \alpha A_i + \mu_i \quad (2)$$

where A_i is a variable that captures each student's ability/effort/motivation and we omit A_i (because of lack of data data) when we run a regression, A_i will get absorbed by the error term and we will actually estimate

$$M_i = \beta LC_i + \varepsilon_i \qquad (\text{where } \varepsilon_i = \alpha A_i + \mu_i) \quad (3)$$

If we add the vectors of control variables described in section 3 and the module notations to (3) we then revert to (1) which is the model estimated in this paper. If $\alpha \neq 0$, then LC_i is correlated with the error term and β is a biased estimator. Adding a large number of control variables as was done in this study could help correct this bias but there is no way of knowing for sure (Clarke, 2015). Another way to correct this bias would be to use an instrumental variable estimator but in this case, given our data limitations, no obvious instrument variable could be found.

That does not mean that the results presented in this paper are irrelevant. If we assume that $\alpha \neq 0$, it seems reasonable to assume that LC_i and A_i are positively correlated with each other (and with the final mark, i.e. students with higher ability/effort/motivation will engage more in viewing lecture recordings and will achieve higher final marks[19]) then we can think of the estimates of $\hat{\beta}$ presented in this paper as the upper bound of the true values of β and interpret the coefficients as the increase in marks for watching an extra hour of lecture recordings at most, i.e., that the true value is likely to be lower than the results presented in section 3.

[19] The fact that the mean final mark of students that accessed lecture recordings was significantly higher than the students that did not access lecture recordings seems to encourage this hypothesis.

Another 'elephant in the room' is the fact that no attendance data is available in this dataset and as such we cannot establish whether the viewing of lecture recordings was done as a complement or as a substitute to attending lectures[20]. This is an important issue as previous studies seems to point towards the fact that the difference matters. Williams, Birch and Hancock (2011) for example, show that lecture recordings are only effective in improving student performance when used as a complement to lectures whilst when used as a substitute, lecture recordings provide no additional benefit).

Finally, it is worth reinforcing that unlike in the US, there is no tradition among British universities of conducting randomised trials to establish whether a new teaching method or education technology is. Ethical approval for such experiments is not forthcoming and that is why this study relied on observing the normal behaviour of students instead on running a controlled experiment. This is turn explains why the methodology implemented in this paper was the only method available.

6. Final Remarks

This paper attempts to add to the existing literature on the impact of viewing lecture recordings on student attainment by focusing on data of all economic modules in a British university context to determine whether the viewing of lecture recordings online helps students.

A number of statistics are worth noting. First, only about 50% of the students accessed lecture recordings. This proportion in in line with the proportion reported in Leadbeater et al. (2013) but is significantly lower than proportions reported in other studies[21]. Secondly, female students were found to use lecture capture significantly more than their male counterparts, a result consistent with Wiese & Newton (2013). Other groups that were found to access lecture recordings significantly more than their peers were international students, students taking modules solely assessed by a final exam, students from a low socio-economic class and students from an ethnic minority. Unexpectedly, mature students and disabled students were not found to use lecture recordings more than other students[22]. Interestingly, students taking quantitative

[20] Unfortunately attendance to lectures is not recorded in a systematic wat at Exeter University although a number of new technologies are currently being tested with a view to collect that information in the future.
[21] Elliot and Neil (2015), for example, report that 84% of first-year economics undergraduate students at Lancaster University, also in the UK.
[22] The result for disabled students is surprising for two reasons: first, because this result remains when we just look at students with a dyslexia or dyspraxia condition and one would expect these students to make a larger use of this resource. Also, one of the main drivers for the

modules access lecture recordings less that students taking more discursive modules as do students doing UG Economics majors and PGT Economics Majors and Minors whilst students doing UG Economic minors were found to use lecture recordings significantly more. One reason for this might be that economics, like results found for other technical subjects like Maths and Engineering (Inglis et al. (2011)), require more face-to-face and regular study so that students that substitute lecture attendance by viewing lecture recordings and 'bulge study' may not be able to learn as effectively and lead to poorer results.

The regression analysis showed that lecture recordings yielded (at most) an almost negligible effect on student performance. For every extra hour of lecture recording viewing over the whole term, students could get an extra 0.1 marks or so (out of 100, ceteris paribus). Although our methodology does not allow us to determine this conclusively, it is very possible, and indeed likely, that that result is simply the effect of a student spending more time studying a subject and that the use of that same amount of time of study in other forms of independent study (e.g. reading a textbook) would achieve the same or even better results. This is important as students tend to perceive that the use of lecture recordings significantly improves their performance.

A number of limitations to this study remain. First, the empirical methodology suffers from an omitted variable endogeneity problem. Given that it was not possible to accurately account for each student's level of effort/motivation/ability, it is likely that the estimates provided for the effect of the use of lecture capture on student performance to be positively biased. This is issue is not limited to this study and is common to a lot of studies that include the estimation of education production functions. The collection of more detailed data on each student (so that a suitable instrument can be found) and/or the realization of randomised trials if possible could be the way forward. Also, the data does not include information on attendance and as such it is not possible to determine whether viewing of lecture recordings was done as a complement or as a substitute to attending lectures. Finally, data on one economics department at one academic institution is the source of all data for this study and it is hard to establish how representative this institution is in the wider higher education context. Although

expansion of the provision of lecture recordings in the UK was precisely so that universities could meet its statutory duty to provide 'anticipatory reasonable adjustments' following changes to the provision to disabled students.

comparisons are difficult given different data collection systems and lecture recording software, future research should focus on having a more robust sample of a multitude of departments in a variety of higher education institutions.

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