Do Supplemental Online Recorded Lectures Help Students Learn Microeconomics?*

Jennjou Chen and Tsui-Fang Lin

Abstract

With the increasing popularity of information technology in higher education, it has become important to study how students use new technologies and how effective these methods are. This study sheds light on the relationship between the use of online recorded lectures and exam performance of students in the case of microeconomics. The study uses a rich panel data set covering Taiwanese students. Our results show that those who skip more classes and males are more likely to use online recorded lectures. As may be expected, most students access online recorded lectures just before exams, rather than immediately after lectures. Our fixed effects model shows a significant and positive relationship between students' use of online recorded lectures and their grades. On average, performance improvement attributable to the use of online supplements is close to 4 percentage points. In addition, watching online recorded lectures just before an exam increases students' performance by 3 to 5 percentage points.

JEL classification: A22, E32, E52

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1. Introduction

Many different technologies are incorporated into the teaching of microeconomics courses, including PowerPoint, chalk-and-talk, online discussion boards. However, it is not uncommon for students to face difficulties the first time they are introduced to complicated mathematical equations and graphs in the classroom. In the past, students sought help from their peers, teaching assistants and instructors, during or after the lectures. With advanced information technology now available, students are able to obtain extra help through e-learning. Nowadays, lectures can be recorded effortlessly through screen recording software while the instructors teach the subject. After the class, students have access to the recorded lectures for review and for exam preparation, any time and any where. In addition, the online recorded videos allow students to view the explanation of class materials as many times as needed. With the increasing popularity of information technology in higher education, it has become important to study how students use new technologies and how effective these methods are.

In spite of the importance of assessing the effectiveness of information technology on students' learning outcomes, only a few studies have explored such subjects specifically in the discipline of economics. For example, Agarwal and Day (1998) studied the effects of implementing internet

enhancements, such as email, discussion lists and web information access, on students' learning. They found that the group that had enhancements available performed better in exams. However, a study by Brown and Liedholm (2002) revealed the danger in relying too heavily on strictly online sources. They compared students' grades in traditional and online courses, and found that those who studied only online secured lower grades in exams. These two contradicting studies highlight the importance of studying how students are using the online materials as well as the result of such usage.

Two more recent studies conducted by Flores and Savage (2007) and Savage (2009) explored students' demand for supplemental online recorded lectures and the effects of such information technology enhancement on students' exam performance. Flores and Savage (2007) estimated students' willingness to pay for streaming lecture video and showed a positive correlation between video use and exam grades. Savage (2009) found that students exposed to downloadable lecture videos perform better on the exam but the positive effect is not statistically significant. However, both studies lack detailed information about students' use of supplemental online recorded lectures; their main conclusions are drawn from comparisons between the treatment and the control groups.

The main objective of this paper is to investigate the relationship between the use of a recent internet enhancement, online recorded lectures, and students' performance in exams. We have used a unique panel data set with details of students' usage of online resources. There are several channels that may affect students' learning. For example, in the case where students use internet enhancement as a substitute for live classroom learning, they benefit from streaming lecture videos but they lose the benefits of classroom interaction. If the provision of supplemental online lecture video does not significantly lower students' attendance rates then this method could complement their learning.

In this paper, we aim to answer the following three questions. First, if and when, do students adopt the e-learning approach and watch online recorded lectures? Second, what is the relationship between students' characteristics and their use of online recorded lectures? Third, does watching online recorded lectures improve students' exam performances? The main contribution of this study is to provide useful insights into the use of information technology in learning microeconomics and to explore the relationship between e-learning styles and students' performance in exams.

When assessing the impact of watching recorded lectures on students' exam performances, potential endogeneity problems arise, causing the ordinary least squares (OLS) estimates to be biased. For instance, in a case where students with strong motivations are more likely to use supplemental online resources and have better grades, the OLS estimates could overestimate the effectiveness of online recorded lectures. To address part of the potential endogeneity problem, we employ a fixed effects model to control for individual time-invariant heterogeneity and exam difficulty. As a result, we are able to obtain better estimates.

In the fixed effects model, variations of usage of online recorded lectures help us to identify the online lecture effects more accurately relative to the OLS estimates. Our fixed effects estimation results show that, on average, accessing supplemental online recorded lectures improves students' grades by 4 percentage points. In addition, the time when online recorded lectures are used matters in students' exam performances. On average, watching online recorded lectures soon after the live lectures does not improve students' grades, while watching them within the week before exams does enhance students' grades.

The details of the data set will be discussed in the next section. In the third section, the statistical models will be presented. The estimation results are then reported and the conclusion is provided in the final section.

2. Data

We conducted a survey of 312 students who took the intermediate microeconomics course at an elite public university in Taiwan in the fall semester of 2007 and spring semester of 2008. In our sample, three microeconomics courses were taught by the same instructor, and each contained 12 three-hour class meetings during the study period.

PowerPoint presentations were used in all class meetings. Each lecture was then recorded, using PowerCam software,[1] while the instructor was teaching the classes. Recorded lectures were uploaded to course websites immediately after each class meeting. The course website was located at the e-learning server provided and maintained by the university. Students needed to use their university email IDs and passwords to log on to the server and access course related information. The server then recorded students' use of online course materials.

It is important to note that students could only watch recorded lecture videos on the web and could not download the files to their personal computers. This is different from most available online recorded lectures that can be downloaded to students' personal computers. As a result, we were able to collect information on when students logged on to the server, whether or not they checked a specific course website, and most importantly, which videos were watched by the students and when. All 312 students' performances for each question in the exams were linked to their use of the online recorded lectures. For instance, we were able to observe whether or not, and how many times, a student accessed recorded files and how well each student did on the corresponding exam questions. In addition, information on students' attendance records corresponding to particular exam questions was also collected.

Exam questions included multiple choice questions and essay questions. When the instructor devised the exams, each question consisted of three parts: the question itself, an answer that was key to the question, and corresponding specific lectures and chapters in the textbooks during the sample semester. Thus, we were able to link students' performance in each question to their use of online recorded files.

In this paper, the dependent variable is students' grades, which are measured by the percentage of correctness in each answer. The percentage of correctness of an answer is defined as credits awarded, divided by the maximum credits for that particular question.

A set of variables were constructed to represent usage of online recorded lectures. In order to be sure that the respondent had accessed recorded lectures for review and exam preparation purposes, all variables refer to files accessed for at least five minutes. Definitions of these variables are as follows:

1. *Times*: the number of times a student accessed recorded lectures corresponding to a particular exam question.

2. *Watch Video*: whether or not the respondent had accessed online recorded files corresponding to a particular exam question.

3. *Total Minutes*: total time, in minutes, the respondent spent watching recorded lectures.

4. *Before the Exam*: whether or not the respondent had accessed recorded lectures less than a week before the exam.

[1] PowerCam is software developed by FormosaSoft Corporation; details of PowerCam software can be found at: http://blog.powercam.cc/en/.

5. *After the Lecture*: whether or not the respondent had accessed recorded lectures within a week after a lecture.

Our data do not allow us to empirically test whether the availability of online recorded lectures discouraged students from attending class lectures given that they could catch missed lectures later by accessing recorded lectures on the web. The main reason is that we cannot observe this group of sample students' attendance behaviour before the internet enhancement became available. In order to take into account the effect of attendance on exam performance, we also included students' attendance records corresponding to each exam question.

Table 1 presents the average attendance and average semester grades by students' use of online recorded lectures. The average attendance rate is 77.86%. According to the instructor's records, 77.86% is not significantly different from those in past semesters when the online recorded lectures were not available. Thus, it seems that the availability of online recorded lectures does not change students' attendance behaviour.

One-third of students in our sample had accessed online recorded lectures in the past. We found that there is no linear relationship between watching supplemental online video files and attending classroom lectures. For the students who never watch the videos, the average attendance rate is 77.93%, which is close to the overall average. The students who access online recorded lectures 6-10 times have the highest attendance rate, 85.91%. The average attendance rate for students with the highest frequency of viewing online recorded lectures is 51.43%. In terms of semester grades, students who never use online recorded lectures have the highest average semester grades at 72.25 points out of a total 100 points.

These results seem to suggest that the provision of supplemental online recorded lectures does not help students learn microeconomics. A possible reason could be that less motivated students might not attend lectures often when online recorded lectures are available to them. They might use these videos as substitutes for formal classroom lectures. Since they are less motivated, they might not care as much about what grades they get. The other potential explanation could be that students are not taught how to use the online recorded lectures effectively since the technology is new to them. Without taking into account other covariates and students' unobserved heterogeneity, we observe a negative association between online lecture usage and students' grades from Table 1. Below, a statistical model is presented to better estimate the relationship between students' use of online recorded lectures and their exam performances.

Table 1: Average class attendance and semester grades (by the number of times a student watches an online recorded lecture)

Number of Times	Number of Students	Average Class Attendance	Average Semester Grades
0	211	0.7793	72.25
1–5	33	0.8121	68.14
6–10	22	0.8591	62.33
11–15	25	0.7120	70.97
16–20	14	0.8143	69.16
21+	7	0.5143	62.15
Total	312		
Mean		0.7786	70.65

Note: The average attendance rates are computed as described below. First, we computed each student's average attendance rate for the semester (i.e. lectures attended/total lectures). Then we computed the average attendance rate for each group.

3. Statistical models

This study uses a micro level data set to explore the relationship between students' use of online recorded lectures and their performance in exams. As described earlier, the OLS model could suffer from potential endogeneity bias. A fixed effects model is, therefore, employed to address part of the endogeneity problem.

A linear model describing the relationship between a student's exam performance and various learning inputs variables is shown as follows:

$$y_{ij} = \eta r_{ij} + \lambda t_{ij} + \alpha_i + \gamma_j + \varepsilon_{ij}, \quad i = 1, 2, \ldots, I, \; j = 1, 2, 3, \ldots, J \qquad (1)$$

I denotes the total number of students and J denotes the total number of exam questions. y_{ij} corresponds to student i's observed exam performance on question j. r_{ij} refers to three *Recorded Lecture* variables: *Watch video*, *Watch video right after lecture*, *Watch video right before exam*. The definitions of these variables are discussed in the previous data section. η captures the association between use of recorded lectures and grades, the major interest of this paper. t_{ij} represents student i's attendance record for question j when the materials of question j were taught. α_i represents student i's time-invariant individual effect, γ_j represents question j's specific effect, and ε_{ij} is a random disturbance term.

We included students' attendance status in equation (1) since it is important in determining students' exam performance. We added the attendance variable and the interaction terms between attendance and viewing behaviour as control variables in our model to better estimate the relationship between online lecture usage and exam performance.

Table 2 presents summary statistics of variables. Since 312 students' exam performances were observed for each exam question, there are 13,490 observations. The first panel shows summary statistics for the full sample. The second panel shows summary statistics when attendance is coded as zero. And the third panel shows summary statistics when attendance is coded as one.

Table 2: Summary statistics

Variables	N	Mean	Standard Deviation	Minimum	Maximum
Full Sample					
Attendance	13490	0.7599	0.4272	0.0000	1.0000
Grades	13490	0.6736	0.4212	0.0000	1.0000
Male	13490	0.4098	0.4918	0.0000	1.0000
Times	13490	0.3202	0.7893	0.0000	7.0000
Watch Video	13490	0.1834	0.3870	0.0000	1.0000
Total Minutes	13490	26.722	79.790	0.0000	1053.0
Before the Exam	13490	0.1645	0.3707	0.0000	1.0000
After the Lecture	13490	0.0634	0.2437	0.0000	1.0000
Attendance = 0					
Attendance	3239	0.0000	0.0000	0.0000	0.0000
Grades	3239	0.6300	0.4390	0.0000	1.0000
Male	3239	0.5536	0.4972	0.0000	1.0000
Times	3239	0.4594	0.9510	0.0000	7.0000
Watch Video	3239	0.2485	0.4322	0.0000	1.0000
Total Minutes	3239	40.577	104.40	0.0000	834.00
Before the Exam	3239	0.2186	0.4134	0.0000	1.0000
After the Lecture	3239	0.1099	0.3128	0.0000	1.0000
Attendance = 1					
Attendance	10251	1.0000	0.0000	1.0000	1.0000
Grades	10251	0.6874	0.4145	0.0000	1.0000
Male	10251	0.3644	0.4813	0.0000	1.0000
Times	10251	0.2762	0.7254	0.0000	7.0000
Watch Video	10251	0.1628	0.3692	0.0000	1.0000
Total Minutes	10251	22.345	69.680	0.0000	1053.0
Before the Exam	10251	0.1474	0.3545	0.0000	1.0000
After the Lecture	10251	0.0487	0.2152	0.0000	1.0000

Note: Students are repeatedly observed by the questions they answered in exams. Therefore, the number of observations is 13,490 rather than 312 in Table 1.

By comparing the summary statistics in the second and third panels, we found that attendance is positively associated with students' performances. Male students, relative to female students, are more likely to skip lectures. Most importantly, we found that students are more likely to access recorded lectures if they skip lectures.

Table 3 shows correlations among key variables. We found that grades are positively correlated with attendance. The set of *Recorded Lecture* variables is negatively associated with both attendance and grades without controlling for other factors. In addition, male students, relative to their female counterparts are more likely to access online recorded lectures.

Table 3: Pearson correlation coefficients for attendance, grades, online video usage, and other variables

Variables	Attendance	Grades	Male	Times	Watch Video	Total Minutes	Before the Exam	After the Lecture
Attendance	1							
Grades	0.0582**	1						
Male	–0.1643**	–0.0423**	1					
Times	–0.0991**	–0.0007	0.0164**	1				
Watch Video	–0.0946**	–0.0142*	0.0165**	0.8559**	1			
Total Minutes	–0.0976**	–0.0121	–0.0139	0.7531**	0.7059**	1		
Before the Exam	–0.0820**	–0.0198**	0.0319**	0.7892**	0.9362**	0.6508**	1	
After the Lecture	–0.1073**	–0.0666**	–0.0051	0.4171**	0.5489**	0.3599**	0.4935**	1

Note: Number of observations is 13,490. "**" at the 5% and "*" at the 10% significance level.

4. Estimation results

Estimation results of both OLS models and fixed effects models are presented in Table 4. Clustered standard errors are computed, using the textbook chapter as the cluster. The following main conclusions are based on the fixed effects model since we relied on variations within each of the students' viewings to identify the online recorded lectures' effects.

Table 4: The effects of supplemental online recorded lectures

Independent Variable	OLS							Fixed Effects						
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
(1) Attendance	0.0591**	0.0616**	0.0611**	0.0672**	0.0655**	0.0706**	0.0709**	0.0151	0.0170	0.0159	0.0189	0.0192*	0.0212*	0.0217*
	(0.0127)	(0.0127)	(0.0127)	(0.0154)	(0.0138)	(0.0157)	(0.0148)	(0.0114)	(0.0110)	(0.0109)	(0.0121)	(0.0109)	(0.0118)	(0.0119)
(2) Watch video		0.0235**							0.0389**					
		(0.0080)							(0.0111)					
(3) Watch video right after lecture			0.0319	0.0351*	0.0631**	0.0272	0.0392**			0.0007	0.0019	0.0218	-0.0017	0.0126
			(0.0192)	(0.0195)	(0.0171)	(0.0201)	(0.0179)			(0.0204)	(0.0203)	(0.0179)	(0.0198)	(0.0170)
(4) Watch video right before exam			0.0042	0.0229	0.0041	0.0407*	0.0353			0.0340*	0.0421**	0.0336*	0.0531**	0.0468**
			(0.0145)	(0.0189)	(0.0145)	(0.0226)	(0.0225)			(0.0187)	(0.0201)	(0.0188)	(0.0194)	(0.0210)
(5) Interaction Term (1)*(2)				-0.0289							-0.0130			
				(0.0172)							(0.0167)			
(6) Interaction Term (1)*(3)					-0.0495**		-0.0181					-0.0338**		-0.0218
					(0.0187)		(0.0145)					(0.0156)		(0.0216)
(7) Interaction Term (1)*(4)						-0.0484**	-0.0414**						-0.0254	-0.0173
						(0.0180)	(0.0175)						(0.0187)	(0.0223)
Hausman Test (OLS vs. Fixed Effects)								35.320	44.610	9.0900	10.760	8.1900	8.6900	8.3900
R-squared	0.2763	0.2766	0.2766	0.2768	0.2768	0.2770	0.2770	0.3596	0.3602	0.3601	0.3601	0.3602	0.3602	0.3602
Sample Size	13,490	13,490	13,490	13,490	13,490	13,490	13,490	13,490	13,490	13,490	13,490	13,490	13,490	13,490

Note: The dependant variable is a percentage of the correctness of an answer. Exam question dummies are included in all regressions. The row of Hausman test reports the statistics for OLS against fixed effects models. "**" is significant at 5% and "*" is significant at 10% type I error level. White (1980) robust standard errors are in parentheses; standard errors also robust to clustering in square brackets.

Attendance has a significant and positive effect on students' learning outcomes in most models. In the OLS model, the grades improvement attributable to attendance ranges from 5.91 percentage points to 7.09 percentage points; in the fixed effects model, the grades improvement attributable to attendance ranges from 1.51 percentage points to 2.17 percentage points. This finding is in line with those in prior literature using either secondary data (Marburger, 2001, 2006; Stanca, 2006) or experimental data (Chen and Lin, 2008).

Another one of our key independent variables, whether or not students utilise online recorded lectures (*Watch Video*), also has a positive correlation with students' performance in exams. The association is statistically significant in both OLS and fixed effects models. It is important to note that after controlling for time-invariant individual effect and question specific effect, the fixed effects model shows that watching online recorded lectures has a greater impact. The improvement in grades associated with using online recorded lectures is close to 4 percentage points. This finding is consistent with results in some recent studies (Flores and Savage, 2007; Savage, 2009).

In addition, we found that when a student uses online recorded lectures matters in students' exam performances. Watching online recorded lectures right after the live lectures improves students' grades in some of the OLS models. However, the improvement becomes insignificant in the fixed effects model. In contrast, on average, watching recorded lectures in the week before an examination improves students' grades by 3 to 5 percentage points in the fixed effects model.

There are several plausible explanations for this finding. First, students may simply be cramming the material before exams. Second, students may become more serious about their studies because a test is approaching and use the online videos concurrently. Third, as students begin to study for tests, they may realise the gaps in their comprehension and rely on the videos to enhance their understanding.

If students are using online videos for cramming, then the availability of online recorded lectures helps students pass the exam and promotes the less desirable learning style which could hamper students' learning in the long term. Whereas if students are using the online recorded lectures concurrently with their notes, then the videos are complementing their studies. And if students are using the online recorded lectures to fill in the gaps in comprehension, then the online videos are acting as review sessions and help students' learning too.

Lastly, we also included several interaction terms to test whether the effect of accessing online recorded lectures differs with attendance records of students. We found that none of the interaction terms is statistically significant, after taking into account time-invariant heterogeneity and the question dummy.

5. Conclusion

With the increasing popularity of information technology in higher education, it is important to study how students use new technologies for learning different subjects, and the results of adopting information technology on their learning outcomes. This study, using a rich panel data set, sheds light on the relationship between the usage of online recorded lectures and exam performance, specifically in the case of Microeconomics and Taiwanese students.

Our results show that one-third of students in our sample had accessed online recorded lectures. In addition, males, and those students who skip relatively more classes, are more likely to use online recorded lectures. With regard to the timing of watching online recorded lectures, most students access them just before sitting exams, rather than after lectures.

After taking into account time-invariant heterogeneity and question-specific effects, we partially addressed the potential endogeneity bias resulting from the correlation between online lecture viewing behaviour and unobserved heterogeneity. Our fixed effects model shows a significant and positive association between students' use of online recorded lectures and their exam performances. On average, the improvement associated with such online supplements is 4 percentage points, which is greater than the class attendance effect for the same group of students. The estimation results show that, after controlling for attendance status, the provision of supplemental online recorded lectures does help students learn microeconomics and improves their grades. For this group of students, those who use online resources relative to those who do not use online resources get better grades. This may imply that students could use online recorded lectures to review covered materials and that enhances their understanding of microeconomics.

Furthermore, the results also show that when students view the online lectures relative to when they take tests affects their exam performance. Accessing online recorded lectures just before an exam increases students' performance by 3 to 5 percentage points while watching online recorded lectures immediately after a class meeting does not show a significant effect in test scores. This might imply that the availability of online recorded lectures enhances students' exam performances and possibly increases the number of students who pass the exam by cramming the materials covered.

Many researchers are concerned about the correlation between lower attendance rates and the availability of internet enhancements since poor attendance rates usually mean students learn less too. This paper adds value to existing literature by investigating the usage of online recorded lectures and exploring the relationship between students' adoption of online technology and their academic performance. Future research needs to be done to better address the causal relationship between internet enhancement, attendance patterns and students' learning outcomes.

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Contact details

Jennjou Chen
Department of Economics
National Chengchi University
Taipei City 116, Taiwan
Email: jennjou@nccu.edu.tw

Tsui-Fang Lin
Department of Public Finance
National Taipei University
New Taipei City 237, Taiwan
Email: tflin@gm.ntpu.edu.tw