Title:

Understanding the heterogeneity of online education: Which students benefit from online economics courses?

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Abstract:

There is fair amount of evidence that online courses negatively affect student performance. However, little is understood about the heterogeneity of online programs and the underlying mechanisms causing this negative impact of online learning. Understanding this may help improve student outcomes. The aim of this study is to investigate the effects of online education on student performance at a small comprehensive university focused on classroom teaching and faculty engagement where online education is a complement to traditional face-to-face curriculum. I clearly address and define the source of treatment heterogeneity in order to understand what underlying mechanisms actually generate the differences in student outcomes. I use a rich data detailing student's entire academic history and background, and a novel instrumental variable strategy that takes advantage of random assignment of students to advisors who teach online. This strategy accounts for the endogenous selection into online courses and estimates the effect of taking an online course for the marginal student, who is most likely influenced by assignment to an online-teaching advisor. My findings suggest that in this setting, students are in fact positively selected, with no apparent differences in achievement once selection factors have been accounted for. These findings suggest that generalizability of effects of online education on student performance depends largely on the context in which the online courses are implemented, and that treatment heterogeneity may be a significant problem when making cross-study comparisons. In line with previous literature, I also find that students with higher need for financial aid and less readiness for college are negatively affected by online courses compared with students in face-to-face courses.

JEL: classification: I20, I23

Introduction

Over the past twenty years, colleges and universities have transformed many courses and curriculum from in-person to the online education format to increase student access to education and, to some degree, to decrease costs. The main assumption of online education is that student outcomes between the two formats are comparable and provide no differences for student learning. There have been many studies that have compared student outcomes in online courses to traditional in-class courses to try to test this assumption (Bettinger, Fox, Loeb, & Taylor, 2017; Caldwell, 2006; Cavus, Uzunboylu, & Ibrahim, 2007; Figlio, Rush, & Yin, 2013; LaRose, Gregg, & Eastin, 2006; Mentzer, Cryan, & Teclehaimanot, 2007; Peterson & Bond, 2014; Schoenfeld-Tacher, McConnell, & Graham, 2001; Xu & Jaggars, 2013). The results are mixed and are usually sensitive to the nuances in estimation methods, comparison groups, and the data that are used for the study. The literature typically tests this assumption by separating students in two groups; those who took online courses and those who took the courses in traditional face-to-face (FtF) format. Some of these studies control for student selection bias via random experiment or quasi-experiment and some use purely observational data. The students in the online course are seen as the treatment group and compared to the traditional FtF control group based on a set of given student outcomes such as exams or final grade in the course. The main problem with this approach is the existence of treatment heterogeneity in "online education" as no two colleges or even two different courses will deliver online education in an identical fashion; by comparing online outcomes to those obtained in-class, the inherent assumption is that the two are perfect counterfactuals. However, knowing that there are differences in student outcomes between online and traditional FtF course delivery is not in and of itself useful to educators as this will not help to improve student outcomes, as it does not translate to a scalable product. What we actually want to know is which aspect of an online course works better for a given group of students; understanding the mechanisms underlying a treatment is of equal importance to the treatment itself. Simply comparing online to traditional FtF delivery will not answer this question due to treatment heterogeneity. Therefore, in this paper I compare student outcomes in an online course to traditional FtF course while clearly addressing and defining the source of treatment heterogeneity to understand what underlying mechanisms actually generate the differences in student outcomes. I examine student characteristics to understand which aspect of online learning works for which type of student. I also describe the selection bias for online education to understand what type of students are better suited for receiving online education.

The movement for online education is driven by a greater desire to reach broader student audience and to lower cost of education delivery (Xu & Jaggars, 2013). The vast majority of online education is taking place at large public institutions and for-profit colleges and universities (Allen, Seaman, Poulin, & Straut, 2016). The private non-profit colleges and universities appear to be slower to adapt, especially the small residential non-profit colleges and universities, as their main selling point and comparative advantage is in their personal interaction with students. If online education is to grow at small non-profit residential institutions, it is crucial to understand whether these students are receiving at least the same learning experience as in a traditional classroom, and what works (and what doesn't work) for different students. Small residential non-profit institutions will not transfer the majority of their courses and degrees online as that would alter their mission and institution. However, having a selection of online courses can add ample value to the institution and to the students even if only a limited number of courses from within each discipline are offered online.

To evaluate the impact of online learning on student performance, I use three years of data collected from Principles of Microeconomics course offered at a small comprehensive university focused on teaching and faculty engagement. The course was offered in a traditional FtF manner during fall and spring, and online during the short winter and summer semesters. At the focal institution, online education is used as a complement to regular FtF curriculum, online courses are not offered during fall and spring semesters and students do not have to take any online courses to complete their degrees. Online education is primarily marketed to the university's own student body with the intent to help students take more courses and to enrich their educational experience. Some students take it to catch up in their work, others to get ahead or complete an additional minor. Due to the focus on faculty interaction and personal attention in learning, online courses are limited to enrollment of twenty students per class and students are not permitted to take more than two online courses in a given short winter or summer semester.

In estimating the impact of online education, I address the potential issue of endogenous selection into online courses. The unobservable characteristics of students can bias the results when estimating student performance in online compared to FtF courses. Using the data acquired from university administrative records including information on student performance, financial aid, personal characteristics, and high school background, I account for the selection bias using a novel instrumental variable approach where I use the random assignment of students to academic advisors. My instrument identifies the effect of online teaching for the marginal student, who is most likely to be influenced by assignment to an online-teaching advisor.

The estimation results imply that online courses do not significantly affect student performance as measured by homework, quiz, and final grades. I also find that students with higher GPAs and lower financial aid needs are registering for the online courses which implies positive selection in to online courses. These finding suggest that there is a heterogeneity in online course offerings across various institutions and results found in prior studies focused on community colleges, large for-profit institutions, and large state institutions (Bettinger, Fox, Loeb, & Taylor, 2017; Figlio, Rush, & Yin, 2013; Xu & Jaggars, 2013) are not necessarily generalizable to all types of universities and settings. In the current setting, where education is student-centered, and students are allowed to self-select into online courses, online courses can deliver similar results to traditional FtF classes.

In addition, I also find that online courses can have a heterogenous impact on students and that some students are better suited for online courses than others. There is some evidence that students who have higher amount of financial aid are negatively affected by online courses. The same applies for students who are in their first and second year of study. This indicates that online education is less suited for younger individuals with lower social economic backgrounds. This provides further evidence as to why community college studies have found a negative impact of online, as community colleges traditionally serve students who require more financial aid and enroll after high school.

I also examine student motivation and time management skills as the mechanisms causing underperformance in online courses. There is some evidence using OLS estimation that students who take online courses are more motivated than FtF in this complementary setting. I measure motivation by persistence in repeating assignments until correct answers are found. However, once I control for selection using the instrumental variable, motivation is no longer significant for online courses. I also estimate impact of online on time management using the amount of time students take to complete assignments as a proxy. The OLS results find that students who register for online take significantly longer

to complete quizzes; however, after controlling for selection with the IV approach, this significance disappears.

This research contributes in several ways to the existing work on online education. First, I examine online education in a setting where online courses are used as a complement to traditional FtF education at a small comprehensive institution focus on teaching. Students come to the university because of the traditional small residential factor, and yet, the online courses have become a success and attracted enrollment. Second, I was able to collect detailed student data including background information, academic information, and financial information. Not only does the data better address the unobservable student characteristics and accounting for the endogenous selection bias through new instrumental variable approach, but it also allows for providing the first insight into two potential mechanisms, self-motivation and time management, that may explain the differences in performance of students between online and FtF. Finally, the data and the setting of the study provide a better understanding of which students are suited for online education and which students face negative learning consequences when taking online courses. Online education can be beneficial and deliver great results for students and institutions, however, institutions thinking about designing online curriculum need to first understand that not all their students maybe suited for online courses.

Background and Data

Setting

I examine online learning for undergraduate students at a small comprehensive residential non-profit private institution that has adopted online learning as a complement to their regular semester courses. The university is a small selective university with wide variety of programs, including liberal arts, engineering, arts, and business. The university is on regular academic schedule with fall and spring semester. Since 2014, the university recognized students can benefit from offering online courses during the short winter break and summer. Prior to that, few courses were offered in the summer as the remote location of the university did not allow for many summer classes, and there were not winter classes. The intention of the university was to allow student to take courses online from full-time faculty who volunteered to teach online instead of taking courses at other institution close to home over summer and winter, and transferring the courses back to the university. This way the education could be kept "in-house" delivered by full-time faculty. Students were given the message that this was an opportunity to get ahead or catch-up in their studies. Online courses are only offered during winter and summer whereas during the fall and spring university delivers education primarily in traditional FtF manner.

The online education at the institution is view as a complement to regular semesters --not a substitute. There are no majors at the university where majority of the courses can be done online. The online course offerings depend completely on faculty volunteers, where the faculty who teach these online courses are paid traditional overload stipends. There is a minimum enrollment set for all courses to make sure that the courses break-even; courses that do not make the minimum enrollment are either not offered or are offered as independent studies. Each course is limited to enrollment of 20 students to preserve the nature of a small classroom size, which is one of the core advantages of the institution. The majority of the students who take the online courses are traditional full-time residential students who otherwise would not take these courses over winter and summer if the courses were offered FtF during those semesters.

Course description: treatment

The data for the study comes from students who enrolled in an undergraduate course in Principles of Microeconomics between winter 2014 and winter 2017. The course was offered seven times online, four times over winter semester and three times over summer with two sections in each summer term. The course was offered FtF in two sections during the fall and in one section during the spring. The timing of the FtF sections are carefully set by the administration to allow all student who require the course for their majors to fit the course into their schedules. All sections of the course were taught by the same instructor FtF and online during the study indicating that instructor heterogeneity is not a concern[1]. No additional funding was provided by the university for course development in the online format. Lack of funding for development of high-quality videos and presentations that would mimic in-class faculty lectures made it challenging to ensure that the online courses were engaging to students. It was also important to run the online courses in an asynchronous fashion due to the nature of winter and summer terms. Finding creative ways to engage students online was important for student success, as demonstrated by Holmberg (1995). Furthermore, student engagement was important given that studies of online education in the community colleges find negative learning outcome associated with online where course design involves faculty taking their FtF slides/notes and putting them into an online presentation (Cox, 2006; Edgecombe, Barragan, & Rucks-Ahidiana, 2013).

To properly engaged students online, the course was designed around the idea of many small assignments which would force students to continuously login and complete tasks. Because this was an asynchronous course, students could complete majority of the assignments from the beginning of the course if they wished to do so. The online course provided a detailed syllabus with clear explanation of all assignments and due dates; students were also provided a one-page outline of all the due dates for each assignment for ease of schedule management. Traditional classroom lectures were replaced with short videos on each topic freely available from the internet. All videos were screened by faculty and matched to each topic covered by the course; students were provided careful outline and links for all the videos. Traditional in-class exams were converted online where time limit was set, and questions were randomized from a pool of available questions. To further engage students, discussion posts were mandatory where students had to watch interesting and relevant TED Talk videos and post their opinions and respond to other student opinions. The idea behind the TED Talks is that in the classroom faculty show excitement and passion for the course often through providing more than just the course material but also through application of the material to real world issues sparking students curiosity and interest[2].

All other aspects of the online course were identical to the FtF course. In both, the online and FtF students covered the same chapters from the same book and were given access to all class material. For both online and FtF sections homework and quizzes were assigned online through a learning platform called Sapling Learning[3]. Students were required to purchase access to Sapling Learning and had to complete ten homework assignments and quizzes over the course of the semester; these assignments didn't change from semester to semester. Homework assignments were not timed and students could attempt each

[1] Faculty evaluations are available upon request from both online and FtF sections and show very positive student feedback across the sections.

[2] In the online evaluations students frequently commented how much they enjoyed the TED Talks and the discussions based on the Talks.

[3] Sapling Learning is owned by MacMillan Learning. I received no help or funding from MacMillan Learning in any form and I selected this software after reviewing competing products based on ease of use and functionality.

question an unlimited number of times with only a five percent reduction in question grade for each additional attempt, and quizzes were timed and only two attempts were allowed.

The last key difference between the two courses is physical presence of the faculty. In the FtF sections students interact twice a week with the faculty member and are provided with office hours where they can see the faculty outside of class and ask questions. Students in the online sections do not have this option. To ensure that students in the online sections still understand that faculty member monitors the course continuously regular communication with students was developed. The faculty member would email the class several times a week with various messages including assignment reminders, explanations on difficult problems, or to notify of some current event that was relevant to the course. The online course also featured a policy where the faculty member would respond to students' emails within 24 hours, though usually this happened much faster. This of course required a large time commitment from the faculty, but it builds personal connection with students which is key for student motivation (Holmberg, 1995). This was only possible because online class sizes are limited to twenty students per section.

Data

In Table 1, I compare the observable characteristics between the students who took online sections to those students who took FtF sections. I obtained detailed data on students' records including financial aid information and High School GPA. My sample includes 295 students who took Principles of Microeconomics in one of the 17 sections that were available from winter 2014 to winter 2017. There were 113 students in the online sections and 182 students in the FtF sections.

Table 1: Student Characteristics

	Total	Online	Face-to-Face	t-test
Students	295	113	182	
Sections	17	10	7	
Outcome measures:				
Homework grade (Sapling)	87.96	88.39	87.69	
Quiz grade (Sapling)	83.16	83.55	82.92	
Final Grade	2.97	3.22	2.81	***
Observable characteristics:				
Male	0.58	0.57	0.58	
Race:				
White	0.77	0.88	0.70	***
Black	0.13	0.05	0.18	***
Hispanic	0.05	0.01	0.07	***
Asian	0.04	0.03	0.04	
Other	0.02	0.04	0.01	
Class Standing:				
First Year	0.07	0.12	0.03	***
Second Year	0.35	0.29	0.38	
Third Year	0.33	0.29	0.35	
Fourth Year	0.26	0.29	0.24	
Parent Access	0.34	0.34	0.34	
Prior GPA	2.95	3.12	2.84	***
Student Type	0.85	0.78	0.88	**
Total Financial Aid	Online/Face-to-Face = 0.71			***
State Aid NY	0.4	0.58	0.32	***
SAT	Online/Face-to-Face = 1.07			***
SAT Math	Online/Face-to-Face = 1.10			***
HS GPA	2.71	2.66	2.74	
HS ranking (Zillow)	6.16	6.63	5.88	***
Unobservable characteristics:				
Homework Attempt (Sapling)	1.98	2	1.96	
Quiz Attempt (Sapling)	1.35	1.35	1.35	
Quiz Time (Sapling)	11.94	12.15	11.27	***

Notes: Table provides means for all variables. Information on Financial Aid, and SAT scores are not disclosed due to privacy of the University. For these variables I only report the ratio of Online average to the face-to-face average and significance.

I am interested in students learning through both delivery methods but there is no ideal measure available in the course to capture this. Instead, I use performance on assignments as approximation to learning. Comparing final course grades is not ideal as the courses varied in how students took exams, and how much the grade depended on discussion posts and classroom participation. There is no clear method for comparing final grades between the two delivery modes. The best measures of student performance are the homework and quiz assignments through Sapling Learning. Online and FtF student had to complete the same number of assignments where questions were identical across the sections. The observable differences in these assignments stem from differences in the education delivery method (the treatment), and from observable and unobservable student characteristics. Table 1 shows that Sapling homework and quiz grades are not significantly different between students online and FtF; each assignment was scored on a scale from 0 to 100 where in both cases students taking the online course performed slightly better. Because final course grade is often used as an assessment measure when comparing online to FtF students (Bettinger, Fox, Loeb, & Taylor, 2017; Figlio, Rush, & Yin, 2013; Xu & Jaggars, 2013) I also calculate the final grade for each delivery method on a 4.0 scale. Online students receive a significantly higher grade than students taking the FtF classes. This is not surprising as forty percent of the course grade depends on exams which are not comparable between the two delivery methods.

Observable characteristics include gender where 58 percent of the sample is male, and 42 percent is female with no significant difference between the class delivery methods. The majority of the sample consists of white students who make up 77 percent, and the next largest racial group is represented by black students who accounts for 13 percent. This is consistent with the overall university population statistics. There is a significant difference between the class deliver mode and race. White students account for 88 percent of online population compared to only 70 percent in FtF, black students represent only 5 percent of online and 18 percent FtF. There is also a significant difference among the Hispanics students who comprise 1 percent of online population compared to 7 percent FtF. There is no significant difference for Asian students. I also collect information on class standing as an approximate measure of students age. First-year students represent the smallest group where majority of them take the course online. There is an even distribution of class standing online for the other three years, whereas more second-year students take the course FtF as compared to fourth-year students; this is expected as Principles of Microeconomics is traditionally as second-year course, however, since the course is not required for most university students, students can choose which year they take the course.

Other observable characteristics include parental access which represents the percentage of students who officially give parents' permission to view student records. I also collect cumulative GPA for students prior to starting the semester they took the course. Students who take the online course have a significantly higher GPA compared to FtF students. Student type represents the proportion of new students who started their college careers with the university compared to transfer students. The majority of the sample includes new students who enrolled as incoming first-year students. Online courses consist of greater number of transfer students, this is expected as online courses are marketed as a way for students to catch-up in their studies.

I was also able to obtain detailed financial aid data from the university with the understanding that I would keep exact amounts confidential. In Table 1, I report the total financial aid students received per year upon enrollment in the university, which includes all federal, state, institutional, and external scholarships, as a ratio of the average aid students received online to the average aid students received in FtF courses. In discussion with financial aid staff, I was informed that the amount students receive in

their initial year remains consistent throughout student's four-year attendance. Students who take the course online receive significantly less total financial aid compared to students in the FtF sections. The sample in the study consists of 78 percent students from NY State which is similar to the overall university population. For the NY State residents, I observe the amount students received in state aid. I created an indicator variable State Aid NY equal to 1 if students received no financial aid from NY State. According to the financial aid staff, students only qualify for State financial aid when their family income is less than $80 thousand annually. In the sample of NY residents, 40 percent of students do not qualify for state aid. In the online courses, 58 percent of NY students don't qualify for financial aid whereas in the FtF sections only 32 percent of students don't qualify.

Students taking online classes also have significantly higher SAT scores (both total SAT and Math SAT). I compute both SAT scores as a ration of average SAT scores of the online students relative to the average SAT of FtF students. The high school(HS) GPA is not significantly different between the two groups, however, students taking online courses have slightly lower GPA. This result would be surprising giving that these students have higher SAT scores, however, using student home address provided on their university application, I was able to obtain Zillow high school ranking corresponding to the school assigned to the address. This ranking is not for the actual high school the students attended, but it does provide an approximation for the school quality in the student's home neighborhood. The Zillow high school ranking indicates that students in the online course lived in neighborhoods with significantly higher-ranked schools, 6.63 out of 10 compared to 5.88 out of 10 for FtF students. High school rankings are correlated with school quality and rigor which may explain the lower HS GPA.

Finally, to account for some unobservable student characteristics, I used the Sapling data to construct approximate measures of self-motivation and time management. The Sapling software allows students to continue to attempt questions until they solve the problem or give up. The homework questions were set up to give students unlimited number of tries with a penalty of five percent grade reduction on each question per additional attempt. This gave students incentives to continue to try to solve problem until they found the correct solution with a minimum loss of grade. Students who quit before solving didn't receive credit for the question. This willingness to keep trying can be used a measure of perseverance and motivation for students trying maximize their class grade. For the quiz assignments, students were allowed two tries per question. The difference in homework and quiz attempts is not significant between online and FtF. The Sapling software also kept track of time students spent on each question and assignment. Homework assignments were not timed and students could take days to complete each assignment which makes it difficult to identify exactly how much time student spent on each homework assignment since the clock on the assignment started when students entered the assignment and stopped with the final submission. Quizzes were timed, and students were given only 45 minutes to complete each quiz and then the quiz would automatically submit. I only count quizzes that students attempted[4]. Students enrolled in the online sections took significantly more time to complete quizzes where average student took 12.15 minutes to complete an average quiz compared to 11.27 minutes for the average FtF student. Ability to manage own time could explain the difference, especially conditional on observable student characteristics.

[4] Majority of the students completed all the quizzes. Few of the quizzes that were missing for some students appear to be missing at random and were not related to difficulty of chapters.

Empirical Strategy

The objective of the study is to identify the effects of the online course taking on student learning in present setting. A secondary aim is to identify for which students online learning works better and how much historically unobservable student characteristics such as motivation and time management differ by course delivery method. Based on Table 1, there is ample heterogeneity between the students enrolling in online compared to FtF courses. Given the potential for endogenous selection into an online course, comparing students directly with unobservable factors could lead to bias estimates. To deal with this selection issue, I propose a novel instrumental variable (IV) approach and specify the following model to estimate the local average treatment effect (LATE) of students taking the course online instead of FtF:

$$Outcome_{it} = \alpha Online_{it} + \boldsymbol{X}_{it}\beta + gpa_{it\text{-}1} + \varphi_{it} + \tau + \varepsilon_{it} \qquad (1)$$

where *Online* is an indicator variable equal to 1 if a student i took the course online in semester t. The specification includes control variables for gender, class standing, race, student type, parental access, natural log of total financial aid, SAT scores, HS GPA, and the Zillow high school ranking. I also control for the previous semester college GPA, a full set of major fixed effects, φ, and τ year fixed effects.

Prior literature addresses the selection bias either through a random assignment of students to either online or FtF sections (Brown & Liedholm, 2002; Hernández-Julián & Peters, 2012; Figlio, Rush, & Yin, 2013) or by instrumental variable approach. As the university does not permit for student randomization to courses and does not offer online course during fall and summer terms, the random assignment approach is not feasible in this setting. The other common method in literature is to use a quasi-experimental design where selection bias of online is accounted for using instrumental variables. Several IVs were used including distance to campus (Xu & Jaggars, 2013), number of seats in a classroom (Streich, 2014), and interaction term between distance and availability of FtF courses on campus (Bettinger, Fox, Loeb, & Taylor, 2017). In the current study, these variables are not appropriate as students don't select when to take online courses, they either take it over winter or summer. During winter and summer students don't stay on campus and cannot have the option of traveling to campus to take the class FtF. All students have the option to take the course FtF during the fall and spring semester. Classes in general never fill up to maximum so the number of seats available is also not a constraint for students. In the rare situations that class do fill up, students can email the faculty to provide permission to enroll which is usually granted.

To address the selection bias individuals taking $Online_{it}$, I propose an instrumental variable $Advisor_{i,T<t}$ which is an indicator variable equal to 1 if a student was assigned to an advisor who taught an online course prior to taking Principles of Microeconomics. In the data, I observer all major and minor faculty advisers for each student. I also observe whether the faculty advisor taught online course in previous semesters. To estimate LATE, the instrument needs to meet five assumptions as provided by Angrist, Imbens, & Rubin (1996).

The first assumption is the Stable Unit Treatment Value Assumption (SUTVA) which implies that student's learning outcomes such as homework and quiz grades in Sapling are unrelated to other students taking the course online or FtF. This assumption would be violated if students for example chose to take one type of course together and helped each other with the assignments. Given the number of homework assignments and quizzes from Sapling, and the relatively small percentage of final grade that each of the assignments is worth, this is highly unlikely. Furthermore, quizzes are timed, and strict honor code policy

is enforced upon detection of cheating which further prevents violation of this assumption. There was no cooperation between students detected by the instructor in any of the sections over the duration of the courses.

The second assumption requires that advisors are randomly assigned to students. This is the case for all incoming first-year students who are assigned advisor based on their specified major. Since all majors have several faculty members, students are assigned to advisors based on the discretion of the dean who is responsible for managing faculty advising loads. This assignment is random as first-year students cannot select who their advisor is going to be when they start their college careers. It is possible for students to switch advisor, but this does not happen very often as advisors want to maintain even advising loads; data on advisor switching is unavailable to test this. Transfer students are also assigned an advisor to help them with their academic trajectory and do not have a choice in their advisor. Students who switch their major are reassigned to a different advisor but this again is assigned at the dean's discretion.

The third assumption is the exclusion restriction which requires that any effect an advisor has on the student learning outcomes is only through the advisor role in influencing the student to take the course either online or FtF. The advisor has no other channel to influence these learning outcomes for students. The university advising process requires that students meet with their primary advisor before they can register for fall and spring classes. This is the meeting where students discuss their graduation plan and discuss the potential for taking courses for winter and summer term. The majority of students register for winter and spring term courses after the advising week in the fall, and the majority of students register for summer and fall after the spring advising week. This indicates that students select their next semester courses during the meeting with their advisor or come with prepared schedule and discuss it with the advisor. The interesting aspect is that students cannot register for spring and fall without going to meet with advisor during advising week because students need to receive a special registration number. However, to register for winter and summer, students don't need any registration numbers and can register on their own, but most still register after advising week. This suggests that advisors and graduation planning influences students to take online courses. There are some students who will take online regardless of whether their advisor taught online before as they simply need the course to graduate. However, there are some students who are marginally influenced by their advisor to take the online courses. The advisors who don't teach online have no incentives to recommend students take online courses outside of making sure students graduate and will suggest online only if students need the course to graduate. However, the university structures the online teaching over winter and summer such that faculty who teach online have incentives to advise students to take these courses. Faculty self-select to teach online and are free to do so in any subject, including hands on fields such as engineering where faculty can create courses that would still be covered online. The incentive for the faculty to teach online courses is the extra monetary pay for each additional course they teach online. The courses are only offered when enough students register to cover the cost of the course. This creates incentives for faculty to recommend to students to enroll in online courses. Faculty who only teach FtF have no such incentives and actually would prefer students only take spring and fall courses, especially for the upper-level electives that are enrollment dependent in spring and fall. Therefore, due to the monetary incentive faculty who teach online have a higher propensity to influence students to take online courses. Even if the students don't take their advisors online course, by discussing the online option with the student, the advisor is increasing the propensity for the student to be aware of possibility of online courses.

The next assumption requires that *Advisor* has some effect on the average probability of student taking an online course. As discussed above, the monetary incentives for the faculty who teach online reveals this probability. The final assumption is monotonicity, which assumes that any student who would take online if his or her advisor does not teach online would also take the online course if the advisor did teach online. This assumes that there are no reversals meaning that if a student assigned to an advisor who teaches online does not take online course, this same student would not change their mind and take the online course if her advisor did not teach online. As discussed above this assumption would require that the faculty who don't teach online would have a stronger incentive to recommend online than faculty who do teach online. This is not likely given the situation of the online education at the university and the reward system to faculty for choosing to teach online.

I use this instrumental approach for all student outcomes including measures of motivation and time management.

Results

Given the online environment and university setting described above, I find that taking a course online instead of FtF results in no significant difference is student learning as measured by homework and final grade when estimating equation (1) with OLS. Table 2 provides the OLS estimates for equation (1). Taking the course online negatively affects student quiz performance where students who take the course online perform 2.5 to 3.3 points lower on quizzes compared to students who take the FtF course depending on specification. In Table 2, I provide two specifications for each of the outcome measures. In the first three columns, I only include variables that are commonly available in the literature (Bettinger, Fox, Loeb, & Taylor, 2017) and then in the last three columns, I add additional variables found in my data. When I add these additional variables, the sample size is reduced due to missing information on financial aid and HS GPAs for some students[5]. The impact on online due to these additional variables is small. The HS GPA variable is significant in all three specification indicating that students High School readiness impacts how they perform in the course.

[5] In discussion with the financial aid office who is responsible for the missing data, I was told that it was unclear why the data were missing as after extensive checking there was nothing particular regarding the students with missing data, it seemed to be some kind of system problem with the records and not with particular students.

Table 2: OLS results for main outcomes

	(1) OLS Homework	(2) OLS Quiz	(3) OLS Grade	(4) OLS Homework	(5) OLS Quiz	(6) OLS Grade
Online	-2.679	-2.544**	0.116	-2.865	-3.306**	0.108
	(1.582)	(1.190)	(0.107)	(1.970)	(1.547)	(0.173)
GPA	2.835**	4.179**	0.483***	2.031	2.342	0.382***
	(1.167)	(1.512)	(0.065)	(1.644)	(1.943)	(0.099)
Male	0.617	2.543	0.083	2.315	2.870	0.248
	(1.587)	(1.478)	(0.127)	(1.549)	(1.670)	(0.179)
First Year	-0.748	-3.403	-0.496	1.158	-4.441	-0.264
	(2.954)	(4.430)	(0.320)	(2.968)	(5.068)	(0.524)
Second Year	1.668	0.710	0.120	1.515	0.429	0.302
	(1.640)	(1.635)	(0.165)	(1.894)	(2.015)	(0.241)
Third Year	0.225	-0.630	-0.029	-0.734	-1.702	0.160
	(1.395)	(1.509)	(0.198)	(1.502)	(1.726)	(0.306)
Black	-1.025	-0.697	-0.217	-0.435	0.237	-0.158
	(1.298)	(2.193)	(0.151)	(1.215)	(2.515)	(0.206)
Hispanic	-1.526	0.467	-0.649**	-1.882	0.812	-0.703**
	(1.932)	(3.496)	(0.276)	(2.373)	(4.837)	(0.282)
Asian	0.063	0.545	0.036	-3.636	-3.499	-0.269
	(2.479)	(3.969)	(0.203)	(3.208)	(4.481)	(0.416)
Other	6.916***	0.746	0.177	5.269**	0.343	-0.288
	(2.331)	(4.378)	(0.160)	(2.263)	(6.144)	(0.294)
Enrolled as New				-3.064	-3.755	-0.745
				(3.167)	(2.773)	(0.512)
Parent Access				-0.115	0.068	-0.242*
				(1.225)	(1.341)	(0.115)
Total Financial Aid (log)				0.063	-0.543	0.032
				(1.780)	(1.152)	(0.185)
Nearby HS score (Zillow)				0.333	0.297	0.030
				(0.361)	(0.438)	(0.038)
HS GPA				3.169***	2.301**	0.298**
				(1.056)	(1.012)	(0.122)
SAT				0.005	0.015***	-0.000
				(0.005)	(0.004)	(0.000)
Observations	279	279	278	206	206	206
R-squared	0.292	0.218	0.397	0.364	0.297	0.480

Robust standard errors clustered at the course level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Although the OLS results are based on observable characteristics available in the data, there is still potential that the unobservable characteristics bias the impact of online on student outcomes. To control for any potential endogenous selection not accounted for with observable characteristics, I estimate all outcome measures instrumenting online with an indicator for whether the student's advisor taught online. Table 3 provides the local average treatment effect (LATE) estimated using IV where taking an online course results in no significant impact on any of the student performance measures.

Table 3: IV Results for main outcomes

	(1) IV Homework	(2) IV Quiz	(3) IV Grade	(4) IV Homework	(5) IV Quiz	(6) IV Grade
Online	-4.081	-7.325	0.181	-12.296	-22.995	-0.992
	(8.075)	(8.076)	(0.628)	(11.325)	(16.448)	(1.176)
GPA	3.044*	4.891***	0.473***	3.050	4.469**	0.501***
	(1.716)	(1.828)	(0.113)	(1.895)	(2.107)	(0.171)
Male	0.664	2.704**	0.081	1.595	1.366	0.164
	(1.496)	(1.233)	(0.121)	(1.369)	(2.009)	(0.154)
First Year	-0.586	-2.849	-0.503*	2.895	-0.815	-0.062
	(2.850)	(4.188)	(0.292)	(2.521)	(4.029)	(0.333)
Second Year	1.636	0.602	0.123	1.780	0.982	0.333
	(1.426)	(1.488)	(0.137)	(1.795)	(2.214)	(0.204)
Third Year	0.196	-0.729	-0.027	-0.336	-0.870	0.207
	(1.227)	(1.420)	(0.169)	(1.719)	(2.580)	(0.299)
Black	-1.111	-0.990	-0.214*	0.041	1.231	-0.103
	(1.290)	(2.028)	(0.128)	(1.269)	(2.552)	(0.199)
Hispanic	-1.934	-0.923	-0.631***	-3.537	-2.642	-0.896***
	(3.166)	(4.776)	(0.236)	(3.449)	(5.666)	(0.280)
Asian	-0.110	-0.045	0.044	-7.075**	-10.678*	-0.670
	(2.498)	(3.794)	(0.225)	(3.517)	(6.435)	(0.647)
Other	6.953***	0.874	0.176	6.408	2.722	-0.155
	(1.980)	(4.157)	(0.148)	(3.986)	(8.617)	(0.269)
Enrolled as New				-4.266	-6.264	-0.886**
				(3.951)	(5.239)	(0.429)
Parent Access				0.413	1.171	-0.181
				(1.178)	(1.699)	(0.155)
Total Financial Aid (log)				-1.197	-3.173	-0.115
				(1.989)	(2.063)	(0.221)
Nearby HS score (Zillow)				0.716	1.096	0.075
				(0.485)	(0.760)	(0.058)
HS GPA				2.390*	0.673	0.207*
				(1.262)	(1.444)	(0.123)
SAT				0.006	0.016***	0.000
				(0.004)	(0.005)	(0.000)
First Stage Results (Dependent variable: Online)						
Advisor	0.114*	0.114*	0.115*	0.107	0.107	0.107
	(0.061)	(0.061)	(0.61)	(0.080)	(0.080)	(0.080)
Observations	279	279	278	206	206	206
R-squared	0.288	0.176	0.396	0.196		0.339
F-Test on excluded instruments	3.53	3.53	3.57	1.79	1.79	1.79
(Prob>F)	0.079	0.079	0.077	0.200	0.200	0.200

Robust standard errors clustered at the course level in parentheses. All models include controls for student's major, and year course was taken.

*** p<0.01, ** p<0.05, * p<0.1

The coefficients for homework and quiz in Table 3 are larger than the OLS estimates but not significant. When looking at columns 4 and 5 with additional control variables the coefficients on homework and quiz are much larger but the first state F-test indicates that the excluded instrument is not significant. This result is mostly likely due to the smaller sample size due to missing data. Looking at the first stage regression results at the bottom of Table 3, the coefficient on Advisor is only significant at ten percent indicating that advisors have only a small influence on why students actually sign-up for the online courses[6].

The results taken together indicate that Online courses affect student's homework and quiz performance negatively but not significantly. Homework and quizzes are a good measure of learning as they capture how much students actually know about the material that is covered in class and not on other characteristics that could impact grade, such as ability to take exams. The coefficient on grade is not significant as well in Table 3 indicating that students' grades are not negatively impacted by online learning. Grade are not an ideal measure of learning, especially in this situation where exams varied across mode of delivery, but are important for student records and graduation.

The interesting aspect of these findings is that although the students who took the online course were positively selected and on average had significantly higher GPAs and final grades in the course based on Table 1, these students didn't learn more than students in FtF. They received a better grade on average because of higher exam grades which differed by delivery mode. They also received better grades because they were prepared more for the course based on their prior GPAs and other characteristics. The actual learning between the two groups was same as measured by homework and quizzes, meaning the same knowledge was taught and learned by both groups which is exactly the goal of the course regardless of delivery mode.

The results convey information about how the online course was setup and taught. In the setting where online is a complement to FtF education, students have no pressure to sign up for online courses if they don't feel comfortable with online as a medium for learning. In fact, from conversations with students, students often say that they won't take online courses because they like the personal interaction with the faculty and want the weekly lectures. This group of students are also the students who often need greater support in their learning and they see online as a barrier to that support. The positive selection of students as evident in Table 1, indicates that online education is well-suited as a learning tool in this complementary setting. It is also important to take into consideration that the insignificant impact of Online found in Table 2 and 3 maybe attributed to how much time the instructor of the courses spent interacting with students online which may have had a great effect on the personal attention aspect that students need in order to succeed. This kind of personal attention would be difficult to replicate in a large university or community college setting and at the same time, it is hard to quantify this impact on students as faculty contact with students was not measured.

[6] As a validity check, I also estimated the impact of *Advisor* has on each of the outcome variables in a subsample that included only students who took the course FtF. The *Advisor* IV should only have impact on the outcome variables through *Online* therefore it should not have any impact on student outcomes for students who took the course only FtF. In all specifications *Advisor* has no significant impact on student outcomes for this group; estimation results are available upon request.

Potential Mechanisms

The literature finding that online education negatively affects student learning often is unable to pinpoint exactly the underlying reasons explaining why student who take online courses don't perform as well as students who take classes FtF (Bettinger, Fox, Loeb, & Taylor, 2017). Two potential explanations for the differences is that online courses require more self-motivates compared to FtF courses and that online courses require greater time management skills by students. Self-motivation is important in an online setting as students don't have a weekly meeting with faculty who reminds them that they need to stay on track; there is essentially less supervision which reduces online students' incentives to perform as well as in a FtF setting. Time management is also a key to success in an online environment as again there are no weekly meeting with faculty and students need to keep track of all assignments on their own.

I use the data from Sapling Learning assignments to estimate the role of these two mechanism which may provide some intuition into the behavior of online students. As an approximation of self-motivation, I collected information on how many times each student attempted a given homework and quiz question in Sapling Learning. Each student could have two attempts on quizzes but on homeworks the number of attempts was unlimited meaning that students who wanted to get the right answer could keep trying until they go the right answer. The limitation of this variable as a measure of self-motivation is that the number of times a student will attempt each question is both conditional on self-motivation and students' ability/knowledge of the subject. For time management, the Sapling Learning provides the number of minutes each student spent on a given question. Again, this is conditional on students' knowledge of the subject but also on how well students manage their time in solving the answer and looking for relevant materials to help them solve the answer. Better-organized students who can manage their time will have an advantage when it comes to solving these problems. For both self-motivation and time management approximations, I estimate equation (1) with same set of controls as in previous tables.

Table 4: OLS Results for Mechanism outcomes

	(1) OLS Homework Attempts	(2) OLS Quiz Attempts	(3) OLS Quiz Time to Complete	(4) OLS Homework Attempts	(5) OLS Quiz Attempts	(6) OLS Quiz Time to Complete
Online	0.134*	0.047**	2.384***	0.165	0.049*	2.809***
	(0.067)	(0.019)	(0.676)	(0.103)	(0.024)	(0.586)
GPA	-0.080	-0.071***	-0.438	-0.019	-0.048	-0.288
	(0.072)	(0.024)	(0.476)	(0.067)	(0.033)	(0.723)
Male	-0.075	-0.044*	-1.091	-0.106	-0.059**	0.096
	(0.050)	(0.023)	(1.153)	(0.101)	(0.028)	(1.635)
First Year	0.378	0.049	-1.982	0.605*	0.089	-0.552
	(0.288)	(0.083)	(1.332)	(0.288)	(0.102)	(1.552)
Second Year	0.068	-0.013	1.562**	0.157*	0.009	2.693**
	(0.074)	(0.025)	(0.692)	(0.078)	(0.033)	(0.931)
Third Year	0.054	0.000	0.978	0.130	0.027	2.456**
	(0.067)	(0.021)	(0.571)	(0.087)	(0.031)	(0.850)
Black	-0.201	-0.028	0.967	-0.234	-0.056	0.228
	(0.131)	(0.042)	(1.296)	(0.141)	(0.049)	(1.349)
Hispanic	-0.273**	-0.039	1.587	-0.353**	-0.038	1.508
	(0.116)	(0.045)	(1.785)	(0.133)	(0.060)	(2.217)
Asian	0.029	-0.012	1.011	0.091	0.065	-2.606
	(0.186)	(0.071)	(1.777)	(0.305)	(0.079)	(1.503)
Other	-0.050	-0.085	-3.578	-0.148	-0.076	-8.582***
	(0.369)	(0.060)	(2.055)	(0.658)	(0.083)	(2.895)
Enrolled as New				0.081	-0.062	-0.516
				(0.367)	(0.057)	(1.946)
Parent Access				-0.078	-0.005	-1.800**
				(0.070)	(0.019)	(0.670)
Total Financial Aid (log)				0.122*	0.011	1.070
				(0.070)	(0.027)	(1.330)
Nearby HS score (Zillow)				0.010	0.001	-0.053
				(0.029)	(0.006)	(0.173)
HS GPA				-0.108	-0.029**	0.659
				(0.085)	(0.013)	(0.715)
SAT				-0.001**	-0.000**	-0.009
				(0.000)	(0.000)	(0.006)
Observations	279	279	278	206	206	206
R-squared	0.282	0.218	0.217	0.350	0.290	0.311

Robust standard errors clustered at the course level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

In Table 4, I provide the OLS results for self-motivation and time management. Homework attempts is only significant with the full sample in column one where as quiz attempts is significant in both column two and five. This indicates that students who take the course online attempt questions significantly higher number of times controlling for their observable characteristics. The previous results found that online didn't negatively impact students learning outcomes once selection is accounted for, however, I did find that students were positively selecting into online courses. Positive selection would indicate that there could be some unobservable characteristics in these students that is motivating them to receive

better grades and so they continue to attempt problems longer without giving up in order to earn the higher grade. The results for time management indicate that student who take the online course spend significantly more time on quiz questions than student in FtF sections. Because this measure of time management only captures how much time students spend on questions, it is difficult to interpret this as it is possible that online students need to spend more time on each question because they aren't as good as FtF students in time management or it is because they take more time to make sure they have answer the questions correctly. Given the positive selection, I would argue that they spend more time on each question to make sure they have it correctly solved and therefore receive a better grade.

Estimates in Table 4 are susceptible to selection bias as were the main OLS results. To account for selection bias, I present the same results but estimated using the IV strategy. In Table 5, all results for self-motivation and time management are re-estimated using the IV approach that was presented earlier. The IV results show no difference in question attempts and time to complete each question between the student who take the course Online and FtF. These two mechanisms are difficult to observe but are potentially very important in explaining the difference in learning gap between online and FtF.

Testing the importance of these mechanisms is undoubtedly harder in the present situation as online education is complementary to regular semesters at the institution. This indicates that only students who are more motivated to take additional courses and minors will predominantly sign-up for online. The timing is also important as student take the online courses during winter and summer holiday where time management is crucial as students are on break which makes managing courses harder.

Table 5: IV Results for Mechanisms

	(1) IV Homework Attempts	(2) IV Quiz Attempts	(3) IV Quiz Time to Complete	(4) IV Homework Attempts	(5) IV Quiz Attempts	(6) IV Quiz Time to Complete
Online	0.081	-0.072	7.747	-0.169	0.075	-1.748
	(0.593)	(0.148)	(7.081)	(0.926)	(0.148)	(9.402)
GPA	-0.073	-0.054	-1.236	0.017	-0.051*	0.205
	(0.119)	(0.036)	(1.099)	(0.134)	(0.031)	(1.110)
Male	-0.073*	-0.040*	-1.272	-0.131	-0.057**	-0.252
	(0.044)	(0.024)	(0.993)	(0.119)	(0.025)	(1.740)
First Year	0.384	0.062	-2.603*	0.666*	0.084	0.288
	(0.280)	(0.083)	(1.579)	(0.362)	(0.089)	(1.899)
Second Year	0.066	-0.015	1.683*	0.166**	0.008	2.821***
	(0.071)	(0.025)	(0.881)	(0.071)	(0.027)	(0.769)
Third Year	0.053	-0.002	1.090	0.145	0.026	2.648***
	(0.059)	(0.018)	(0.695)	(0.098)	(0.027)	(0.817)
Black	-0.205*	-0.035	1.295	-0.217	-0.057	0.458
	(0.111)	(0.045)	(0.982)	(0.144)	(0.040)	(1.411)
Hispanic	-0.289	-0.073	3.146	-0.412**	-0.034	0.708
	(0.228)	(0.066)	(2.728)	(0.179)	(0.054)	(2.234)
Asian	0.023	-0.027	1.673	-0.031	0.074	-4.267
	(0.214)	(0.085)	(2.635)	(0.474)	(0.103)	(3.402)
Other	-0.048	-0.082	-3.722*	-0.108	-0.079	-8.032***
	(0.318)	(0.051)	(2.049)	(0.503)	(0.076)	(2.788)
Enrolled as New				0.039	-0.058	-1.096
				(0.260)	(0.054)	(2.506)
Parent Access				-0.059	-0.006	-1.544
				(0.097)	(0.019)	(1.043)
Total Financial Aid (log)				0.077	0.014	0.461
				(0.145)	(0.028)	(1.945)
Nearby HS score (Zillow)				0.024	-0.000	0.132
				(0.048)	(0.008)	(0.343)
HS GPA				-0.136	-0.027*	0.282
				(0.121)	(0.015)	(0.869)
SAT				-0.001**	-0.000***	-0.009
				(0.000)	(0.000)	(0.006)
First Stage Results (Dependent variable: Online)						
Advisor	0.114*	0.114*	0.114*	0.107	0.107	0.107
	(0.061)	(0.061)	(0.061)	(0.080)	(0.080)	(0.080)
Observations	279	279	278	206	206	206
R-squared	0.280	0.119	0.029	0.298	0.286	0.203
F-Test on excluded instruments	3.53	3.53	3.54	1.79	1.79	1.79
(Prob>F)	0.079	0.079	0.078	0.200	0.200	0.200

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Heterogeneity in Online Courses

Here, I probe whether online courses affect all students equally or whether there are differences by observable student characteristics in how students are affected by the mode of educational delivery. I stratify the students by various groups and re-estimate the main equation (1) for the learning outcomes tested in Tables 2 and 3. I first focus on financial aid as this information is seldom observable in other studies indicating that it is unknow how students from various income groups respond to online education. The sample size in the study makes it difficult to sub-categorize the student population into many different groups and therefore, I only break the sample by observable characteristics into above and below medium for the given characteristic.

In Table 6, I use the financial aid variable to stratify the sample into student who received above medium financial aid and students who received blew medium financial aid. The financial aid variable used for stratification is the total federal aid received which according the financial aid is awarded based on students' family income where students who come from higher income families receive less federal financial aid. This does not capture scholarships or any other potential merit-based aid, only need-based aid. I provide both OLS and IV estimates in Table 6 where I find that students who receive above medium financial aid are negatively affected by online courses as measured by homework performance. These results are in line with previous literature (Xu & Jaggars, 2013) and further provide evidence that even in complementary setting where students do not have to take online courses to graduate, student who come from less well-off backgrounds are negatively impacted by online education. This is important for higher education to understand as many institutions that have developed online programs do not understand the heterogeneity that exists in student ability to take online courses and that family income is one dimension that is important when placing students into online courses. Students who come from less well-off families need greater support in their education and should not be place in online courses when FtF options are available.

Table 6: Heterogeneity by Financial Aid

Financial Aid:		Below Medium				Above Medium		
	(1) OLS HW	(2) IV HW	(3) OLS Quiz	(4) IV Quiz	(5) OLS HW	(6) IV HW	(7) OLS Quiz	(8) IV Quiz
Online	-0.123	-2.811	-0.792	-27.905	-8.616*	-19.041*	-3.928	-28.457
	(1.586)	(7.820)	(1.874)	(21.133)	(4.757)	(11.003)	(3.054)	(19.026)
GPA	3.766*	4.173**	3.320	7.428*	0.595	1.069	1.835	2.950
	(2.060)	(1.723)	(2.056)	(4.296)	(2.046)	(1.672)	(2.739)	(2.428)
Male	1.723	1.644*	1.715	0.920	3.382*	1.805	5.040	1.330
	(1.149)	(0.906)	(1.874)	(2.811)	(1.738)	(2.859)	(3.278)	(5.444)
First Year	2.706	3.692	-5.877	4.069	-9.842	-15.646	2.386	-11.269
	(4.593)	(3.665)	(7.012)	(11.743)	(5.899)	(9.523)	(5.932)	(15.805)
Second Year	2.270	2.666	0.303	4.288	-3.784	-6.804	0.498	-6.608
	(2.610)	(2.064)	(2.890)	(2.894)	(3.078)	(5.787)	(3.034)	(10.056)
Third Year	-1.171	-0.829	-3.207	0.239	-3.274	-5.581	1.089	-4.341
	(2.441)	(2.142)	(3.123)	(5.184)	(3.185)	(4.921)	(2.981)	(7.893)
Black	-14.884***	-13.743***	-9.907***	1.601	-1.100	-1.581	0.481	-0.651
	(3.073)	(4.185)	(3.256)	(14.222)	(1.828)	(1.682)	(2.608)	(2.967)
Hispanic	-10.013**	-11.505*	-5.546	-20.592	-1.949	-3.377	1.168	-2.193
	(4.136)	(6.772)	(6.083)	(17.312)	(2.833)	(4.107)	(5.437)	(7.174)
Asian	-4.381	-5.238**	-2.927	-11.577*	5.133	5.079	5.054	4.927
	(3.681)	(2.332)	(5.436)	(6.186)	(3.221)	(3.177)	(4.135)	(4.430)
Other	4.229	4.897	8.477***	15.217*	3.956	3.473	-9.868**	-11.005***
	(2.954)	(3.328)	(2.435)	(8.201)	(3.152)	(2.718)	(3.802)	(3.415)
Enrolled as New	-16.854*	-15.879**	-24.643**	-14.819	-4.420	-7.560	0.004	-7.385
	(9.241)	(7.612)	(8.586)	(14.194)	(3.981)	(4.897)	(4.424)	(7.061)
Parent Access	-2.626	-2.504**	-0.017	1.216	2.090	2.671**	0.513	1.880
	(1.762)	(1.204)	(1.964)	(2.554)	(2.011)	(1.332)	(1.432)	(2.661)
Total Financial Aid (log)	-0.951	-0.904	-3.480	-3.003	-2.597	-11.206	2.907	-17.350
	(1.488)	(1.104)	(2.009)	(2.462)	(9.696)	(12.495)	(13.556)	(25.051)
Nearby HS score (Zillow)	0.434	0.578	-0.119	1.337	0.454	0.773*	0.361	1.112
	(0.691)	(0.480)	(0.659)	(1.674)	(0.435)	(0.406)	(0.382)	(0.865)
HS GPA	4.112*	3.692*	6.155***	1.913	3.474**	3.120*	1.454	0.622
	(2.041)	(1.885)	(2.035)	(4.021)	(1.499)	(1.832)	(2.160)	(2.964)
SAT	0.001	0.001	0.015*	0.015	0.009	0.011	0.012	0.017
	(0.009)	(0.007)	(0.008)	(0.011)	(0.006)	(0.007)	(0.012)	(0.016)
First Stage Results (DV: Online)								
Advisor		0.197		0.197		0.087*		0.087*
		(0.166)		(0.166)		(0.047)		(0.047)
Observations	100	100	100	100	106	106	106	106
R-squared	0.559	0.543	0.598		0.440	0.344	0.306	
F-Test on excluded instruments		1.42		1.42		3.35		3.35
(Prob>F)		0.251		0.251		0.087		0.087

Robust standard errors clustered at the course level in parentheses. All models include controls for student's major, and year course was taken. *** p<0.01, ** p<0.05, * p<0.1

I also tested for heterogeneity in gender, race, prior GPA, and class standing which approximates age. There were no differences between student learning outcomes by gender and prior GPA. The sample size is too small to make conclusive evidence regarding differences by race as majority of the sample consists of Caucasian students. I do find that students in the first and second year of their studies are worse off in online courses compared to students in the last two years of study. I don't present the results here as only the OLS results for Quiz were significant. There was also some evidence for this when I evaluated students by their individual class standing. This indicates that students who are older and more experienced with college are better suited for online education. This is important as large part of online education nationally takes place at community colleges were students have less experience with college and maybe at a disadvantage by taking online courses.

Conclusion

I use a rich set of data on sample of students from small private non-profit institution where online education is a complement to students' regular fall and spring semesters to estimate the effects of online education on student learning in a Principles of Microeconomics course. I find that in this complimentary setting student who take course online experience similar learning outcomes as student who take the course in a FtF setting. My results are obtained using OLS and by controlling for endogenous selection into online format with a new IV strategy where I use students' assignment to random advisors who have taught online courses prior to students taking Principles of Microeconomics. The results are important as they provide further evidence that online delivery mode can work for students, but the setting and implementation of online are important factors for student success. Recent literature on online education has found that students who take online courses are negatively affected but my results indicated that this is not necessarily so and the heterogeneity in online setting and delivery should be considered when evaluating online education. Much of the literature has focused on community colleges, for-profit, and large state institutions that make up large portions of students in higher education. However, although my study is at a small non-profit institution which constitutes a much smaller market for online education, the results are still important as they show that online can be delivered in a manner that won't negatively affects student learning.

I also investigate two of the mechanisms that could explain the differences in student performance between online and FtF - self-motivation and time management. I find that students are positively select into online education at the institution where students with better prior GPA, SAT scores, and less financial aid tend to enroll in online courses when online is not a required to graduate but is only there to allow students to take more courses during their college careers. Given this positive selection, I would expect that student who take online courses are more motivated and have better time management abilities. There is some evidence for this in the OLS results when the bias is not accounted for; however, once I control for the bias using the IV, I find that there is no difference in self-motivation and time management between student taking on online and FtF courses.

I also explored the heterogeneity effect of online education focusing on which students are significantly negatively or positively affected by online education. The unique feature of the data allows for stratifying the sample by amount of federal financial aid students receive and the results show that students with greater need perform significantly worse online than FtF. The policy implications of this are significant as this shows that students from less well-off families suffer a learning penalty for taking online courses. Furthermore, the major growth of online education over the past two decades has been at community

colleges, for-profit, and large state institutions where large portion of the student body comes from families that need greater financial aid. Students who attend private non-profit selective institutions usually need less financial aid and those institutions haven't converted as much of their programs online which indicates that online education maybe contributing to increasing learning gap between students from different social economic background. Additional work is required to test this hypothesis further.

The results in this study should be understood in the setting that I tested online education. These findings will help institutions of higher education in structuring their online program and to think about how to deliver online in a way that is beneficial to all students. There are many institutions for which these results will have less applicability as many institutions cannot offer all their online programing only in terms of complementarity as well as, when they offer their online programs many institutions count on economies of scale to make online education profitable and therefore cannot limit the class size as the setting of this study. When it comes to online education, the role of the faculty is as important, or more, as when classes are offered FtF. The faculty needs to communicate with students and take an active role to make sure that students are engaged in learning.

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