COMPARISON OF STUDENT PERFORMANCE IN AN ECONOMETRICS CLASS PRE AND POST REMOTE TEACHING DUE TO COVID-19

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Abstract:
The COVID-19 pandemic resulted in an emergency shift to remote teaching in March 2020. Past research determined that this shift negatively impacted students' learning in Spring 2020. In this paper, I investigate the persistence of this negative effect by comparing students' performance in an econometrics class after the return to in-person teaching (Fall 2021) with the last pre-pandemic semester when classes were fully in-person (Fall 2019). Student performance is significantly lower in Fall 2021, but certain subgroups of students, such as those with a lower prior GPA and seniors, performed even worse. Instructor, course structure, assessments, and majority of the material taught remained the same over the two semesters.

Introduction

The emergency shift to remote teaching had adverse impacts on student learning at the postsecondary level (Orlov et al., 2021; Silva et al., 2024). These negative effects continued even after the return to in-person teaching. For example, at the K-12 level, students from Grades 3-8 who took the Measures of Academic Progress (MAP) assessment test had a decline of 0.20 to 0.27 standard deviations (SD) in Math in Fall 2021 relative to Fall 2019. This decline was larger than that for Reading, which declined by 0.09 to 0.18 SD over the same time point (Kuhfeld et al., 2022).

To the best of my knowledge, there is no study that has tried to quantify the continued effects on student outcomes in college level economics courses after students returned to in-person learning. Both Orlov et al. (2021) and Silva et al. (2024) sample students when they were still taking remote classes due to the pandemic and compare them with students from pre-pandemic semesters. On the other hand, my study compares two in-person semesters – the first semester that students were back in-person after the pandemic (Fall 2021) with the last semester when students were taking classes fully in-person prior to the pandemic (Fall 2019). Ferrer et al. (2023) survey students in Spain with the aim of exploring factors that may have contributed to their change in academic performance relative to pre-pandemic times.[2] However, their paper does not quantify the performance change, which is the main focus of this paper.

I compare students' performance over the same time points used in Kuhfeld's study in an intermediate level core course offered in the Economics department, namely, Empirical Economics

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[2] The dependent variable in their paper is a self-reported question that asks students "How has the Covid situation affected your qualifications?

2, which is an introductory applied Econometrics class. Additionally, I analyze whether a student's performance varies according to their characteristics, namely, their year of study and prior performance. My results indicate that controlling for students' demographics, past academic background, and effort in the course, the overall course score (OCS) is about 8 points lower in Fall 2021 relative to the pre-pandemic semester. While this estimate cannot be interpreted as a causal effect from the pandemic, it provides evidence that student outcomes were lower once classes resumed in-person relative to a pre-pandemic semester. Subgroup analyses reveal that the negative effects were worse and statistically significant for certain subgroups, namely, seniors and those with weaker academic backgrounds.

Data and Econometric Methodology

Data[3] for this study comes from students in an Introductory Econometrics class taught over two semesters at a large private university in the US – Fall 2019, which is the last in-person semester before remote teaching and Fall 2021,[4] which is when the university resumed full in-person teaching from remote teaching, but with strict protocols to prevent COVID outbreaks. This class[5] is mandatory for Economics majors, but optional for minors. It is the second course in the two-part empirical sequence in the department, the first one being a Statistics class, which serves as a prerequisite to this Econometrics class. A semester consists of 15 weeks of teaching and the 16th week is designated for final exams. I taught two sections of this class each semester for a total of four sections. Each lecture session was for 50 minutes and held on Mondays, Wednesdays, and Fridays. Lectures were not recorded in either semester.

There were some changes in course structure over the two semesters. In Fall 2021, unlike in Fall 2019, students had the option of attending a 50-minute weekly discussion session conducted by teaching assistants (TAs), who were advanced PhD students in our department. No incentives were given to students to attend, and no graded assessments were conducted in these sessions. They were simply an opportunity for students to practice Stata coding and additional problems. TAs reported very low attendance. Additionally, I covered more material in Fall 2019, and students had no access to class notes, since they were written on chalkboard during class and erased. To accommodate students who got COVID in Fall 2021, class notes were written on an iPad and uploaded on the course learning platform every week. The positive effect from discussion sessions is expected to be minimal or nonexistent because of very low student participation rate. Moreover, some evidence suggests that uploading lecture notes leads to complacency on students' part in terms of handwriting their own notes, which reduces their learning (Mueller and Oppenheimer, 2014). The coefficient of the dummy variable for Fall 2021 captures all these changes and cannot be interpreted as the causal effect from the pandemic.

Data for this study was collected from students' University records and their performance in this course. The paper uses information from students who gave consent. Students were

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[3] Institutional Review Board (IRB) approval was granted under expedited review by the University's IRB for this project. The data was originally collected for another project that had to change time frames because of the pandemic. The original project was determined to be IRB exempt. The university registrar's office required data collection from students who signed a consent form, and no grading incentives could be given to students for participating in this study. This resulted in a low participation rate - 57% of the total students consented to participate in this study.

[4] Data collection continued over Spring and Fall 2022 semesters, but changes in these two semesters relative to Fall 2019 make comparisons untenable. Preliminary comparison of average scores indicate that the decline continued over the two semesters.

[5] Students in the Economics-Mathematics joint major take a more mathematical version of this Econometrics class.

informed about this study in-class and consent forms were distributed. They could read the consent form and bring back the signed form any time before the semester ended. As per the instructions from the university registrar's office, no incentives were given to participate in this study. Participants are not identifiable. The sample size[6] in this study is 58 students – 32 and 26 students from 2019 and 2021, respectively.

My main dependent variable is OCS, which is a weighted sum of all assessments with a maximum of 100. OCS is calculated as follows: 0.15*average of the three highest problem set scores + 0.20*final essay score + 0.10*draft score + 0.20*midterm exam score + 0.35*final exam score. One of the main assessments in this class is an empirical essay, where students apply the econometric tools learnt in class using Stata and the Current Population Survey (CPS) data. A draft of the essay is due in week 10 of the semester, and the final essay is due on the last day of class. Along with the essay, there are four problem sets (three of them require the use of Stata), a midterm exam in week 8, and a final exam in the final exam week of the semester. More information about this class is available in Dey (2025).

My main independent variable of interest is an indicator variable for Fall 2021, which is 1 if a student is taking the class in Fall 2021 and 0 if in Fall 2019. Other covariates include dummy variables for student's gender, their year in college, and if they are an Economics minor with the base being an Economics major. The total number of lectures where attendance was taken were 39 and 37 in Fall 2019 and Fall 2021, respectively and were used to calculate the percentage of lectures attended. As stated before, the prerequisite of this course is a Statistics class offered in the Economics department, but Statistics courses offered elsewhere in the Math department and the Business school are also acceptable prerequisites. Prior GPA and the prerequisite grade both vary from 0 to 4 and were collected from student records. Students with missing observations on these two variables were coded as 0 and an indicator variable was created and included in the regression models. Students' effort[7] in the course was proxied by the total number of hours they studied for the final exam.

Table 1 lists the summary statistics of the variables in the study. OCS in Fall 2021 is almost 6 points or 7% below Fall 2019's, and the decline is statistically significant at the 5% level. This decline is despite the fact that students in Fall 2021 attended a larger percentage of lectures, had a higher prior GPA[8] and prerequisite grade, and self-reported studying more hours for the final

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[6] Total number of students over the two semesters was 102: 47 and 55 over 2019 and 2021, respectively. 57% of the total students or 58 students in the two semesters consented to participate in this study. I do not have permission to use information from non-consenting students. Overall, I expect consenting students to be academically stronger and doing better in the course as compared to non-consenting students in both semesters.

[7] During the final exam, students answered questions pertaining to their effort in the class. Three questions were asked during the final exam, namely, the total number of hours students studied for the final exam, the number of hours per week they studied for the class (outside of class time), and the total number of hours they spent working on their empirical essay. Hours studied for the final exam was the only variable that was significant. Since the final exam hours variable asks students the most recent information, measurement error is likely to be lower for this variable relative to the other two.

[8] The University provided a credit-no credit (CR-NC) option for Spring 2020, wherein students could designate any grade that they earned in a course that is not an F as CR. An F grade could only be designated as an NC. Students could choose to not change their grade and retain their original earned letter grade. If students chose CR, then their grade on that course did not count towards their GPA, but the class still fulfilled credit requirements. NC did not affect GPA or count towards their credit requirements, and they had to retake that class. This would have inflated the GPA of students in Fall 2021 relative to Fall 2019 because only students who did not do well are likely to choose CR. Three students in our sample chose CR over Spring 2020 and all three were females. None of these three chose CR for the prerequisite of this class. Trost and Wooten (2024) found that females with a lower grade were more likely to choose this option. I created a dummy variable which was 1 for those three students and 0 otherwise and included it in the

exam. These results are not surprising. In a 2021 survey (Gockley and Schneider, 2022), 78% and 56% of Economics faculty felt that students were retaining much less material from prerequisites and learning less from their classes, respectively, relative to pre-pandemic times. However, because of dilution of grading standards, the grades that students received stayed the same. Using data from Turkish universities, Karadag (2021) provides evidence of grade inflation for Spring 2020 relative to Spring 2019 semesters.

Table 1. Summary Statistics[a]

Variables	(1) Full Sample	(2) Fall 2019	(3) Fall 2021
OCS	80.938	83.523	77.757**
	(9.484)	(8.396)	(9.929)
	[54.950 93.800]	[60.275 93.800]	[54.950 92.300]
Fall 2021	0.448	---	---
	(0.502)		
	[0 1]		
Female student	0.603	0.656	0.538
	(0.493)	(0.483)	(0.508)
	[0 1]	[0 1]	[0 1]
Freshman	---	---	---
Sophomore	0.310	0.281	0.346
	(0.467)	(0.457)	(0.485)
	[0 1]	[0 1]	[0 1]
Junior	0.466	0.469	0.462
	(0.503)	(0.507)	(0.508)
	[0 1]	[0 1]	[0 1]
Senior	0.224	0.250	0.192
	(0.421)	(0.440)	(0.402)
	[0 1]	[0 1]	[0 1]
Economics minor	0.034	0.031	0.039
	(0.184)	(0.177)	(0.196)
	[0 1]	[0 1]	[0 1]
Percentage of lectures attended	90.996	89.423	92.931
	(12.386)	(15.187)	(7.532)
	[38.462 100]	[38.462 100]	[75.676 100]
Prior GPA[b]	3.419	3.393	3.453
	(0.424)	(0.430)	(0.422)
	[2.320 3.930]	[2.390 3.930]	[2.320 3.910]
Prior GPA with missing observations correction	3.360	3.393	3.320
	(0.615)	(0.430)	(0.793)
	[0.000 3.930]	[2.390 3.930]	[0.000 3.910]
Indicator variable for missing GPA	0.017	---	0.038

regression models. The estimates were very similar to what is presented in the paper and is available upon request. No students in my sample chose an NC in any course.

	(0.131)		(0.196)
	[0 1]		[0 1]
Prerequisite grade[c]	3.443	3.390	3.518
	(0.541)	(0.573)	(0.495)
	[2.000 4.000]	[2.000 4.000]	[2.300 4.000]
Prerequisite grade with missing observations correction	3.147	3.284	2.977
	(1.103)	(0.823)	(1.372)
	[0.000 4.000]	[0.000 4.000]	[0.000 4.000]
Indicator variable for missing prerequisite grade	0.086	0.031	0.154
	(0.283)	(0.177)	(0.368)
	[0 1]	[0 1]	[0 1]
Total number of hours studied for the final exam	17.293	16.563	18.192
	(14.084)	(13.421)	(15.079)
	[4 72]	[4 60]	[4 72]
Number of students	58	32	26

[a]: Table shows averages of variables, standard deviations are in parenthesis. The minimum and maximum of variables are in [ ]. ***, **, * indicates whether a t-test that checks the difference between columns (3) and (2) is significantly different at 1%, 5%, and 10%, respectively.
[b]: Sample size for prior GPA is 57, 32, 25 in columns (1) – (3), respectively.
[c]: Sample size for prerequisite grade is 53, 31, 22 in columns (1) – (3), respectively.

Table 2 presents average OCS according to two subgroups – class standing and prior GPA. The table shows that Seniors taking this course earn lower average scores relative to students with lower class standing for all three samples – overall, Fall 2019, and Fall 2021. However, the difference is not statistically significant for Fall 2019. Students typically take this class in their Sophomore year, so those enrolling as Seniors may have changed majors or added it as an additional major later. In our sample, we also find that Seniors have a lower average prior GPA, and the differences are statistically significant.

The second panel of Table 2 demonstrates that those who have a higher prior GPA—defined as a GPA of at least 3.3—have higher average OCS for all three samples. However, the difference in OCS between higher and lower GPA students is lower in Fall 2021 relative to Fall 2019. This again indicates that prior GPA was a better indicator of class performance pre-pandemic.

Table 2. Average OCS according to Subgroups[a,b,c]

	Overall	Fall 2019	Fall 2021
Whether student is a Senior or not a Senior			
(1a) Senior = 0	82.842	84.444	81.011
(1b) Senior = 1	74.348***	80.759	64.090***
Whether prior GPA is at least 3.3 or less than 3.3			
(2a) Prior GPA < 3.30	74.679	76.709	71.888
(2b) Prior GPA ≥ 3.30	83.987***	87.092***	80.365**

[a]: Sample size is 45 and 13 students who are not Seniors and Seniors, respectively in the overall sample. Similar sample sizes for Fall 2019 and Fall 2021 are 24, 8 and 21, 5, respectively.
[b]: Sample size is 19 and 39 students for less than 3.3 and at least 3.3 prior GPA, respectively in the overall sample. Similar sample sizes for Fall 2019 and Fall 2021 are 11, 21 and 8, 18, respectively.
[c]: ***, **, * indicates whether a t-test that checks the difference in means between groups (1a) and (1b), (2a) and (2b) are significantly different at 1%, 5%, and 10%, respectively.

The empirical methodology in this paper consists of Ordinary Least Squares (OLS) regression models with OCS as the main dependent variable and the coefficient of Fall 2021 as the parameter of interest. To explore whether certain subgroups of students did worse after the return to in-person teaching, I experimented with interaction terms between Fall 2021 and other covariates[9] such as Seniors and past GPA.

Results
Table 3 presents results[10] from all regression models. Models 2-4 control for all covariates listed in Table 1, but estimates from only selected covariates are shown in Table 3. Model 1 does not control for any covariates and captures the difference in average OCS between post- and pre-remote teaching semesters. Model 1 understates the decline, since OCS is almost 8 points lower in Fall 2021 relative to Fall 2019 in Model 2. Moreover, from Model 2, Seniors perform worse than Sophomores, and the difference is statistically significant at the 10% level. Class attendance and prior GPA have expected positive effects and are statistically significant at the 1% and 5% levels, respectively. The coefficient of number of hours studied variable has a negative effect, which is significant at the 10% level. This is consistent with findings in Krohn and O'Connor (2005). Students who were not performing well or not engaging with the class put in more work for the final exam, but still earn less points.[11]

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[9] I also experimented with other subgroups like gender and the number of hours studied for the final exam. The interaction term between Fall 2021 and the female dummy variable was negative indicating that females did worse in Fall 2021, which is similar to the finding in Silva (2024). Additionally, the interaction term between Fall 2021 and number of hours studied for the final exam was positive indicating that those who put in more effort in Fall 2021 had a lower decline in OCS. However, both interaction terms were not statistically different from 0. Hence, the results are not part of this paper but are available upon request.

[10] Restricting the sample to those observations where standardized predicted residuals are more than -2 and less than 2 does not change the main results. Estimates excluding outliers are available upon request.

[11] I ran a regression of final exam scores instead of OCS on all covariates in Model 2 of Table 2 along with scores on the midterm exam. Midterm exam scores have a significant positive effect. After controlling for midterm exam scores, the hours studied variable changes sign from negative to positive but is insignificant.

Table 3. Regression Models

Variables	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
Fall 2021	-5.766** (2.406) [0.020]	-7.761*** (1.666) [0.000]	-2.247 (2.761) [0.420]	-37.538** (15.044) [0.016]
Junior		0.517 (2.108) [0.807]	2.483 (2.561) [0.338]	-0.039 (2.062) [0.985]
Senior		-4.932* (2.672) [0.071]	0.553 (2.999) [0.855]	-3.996 (2.632) [0.136]
Junior*Fall 2021			-4.748 (3.641) [0.199]	
Senior*Fall 2021			-14.823*** (4.516) [0.002]	
Prior GPA with missing observations correction		6.926** (2.842) [0.019]	3.920 (2.890) [0.182]	2.269 (3.613) [0.533]
Prior GPA*Fall 2021				8.657* (4.348) [0.053]
Percentage of lectures attended		0.264*** (0.072) [0.001]	0.329*** (0.069) [0.000]	0.301*** (0.072) [0.000]
Prerequisite grade with missing observations correction		3.350 (2.045) [0.108]	4.406** (1.953) [0.029]	4.562** (2.074) [0.033]
Total number of hours studied for the final exam		-0.115* (0.061) [0.063]	-0.119** (0.056) [0.038]	-0.139** (0.060) [0.024]
Constant	83.523*** (1.611) [0.000]	27.427*** (9.786) [0.007]	25.756*** (9.347) [0.008]	35.996*** (10.416) [0.001]
#Observations	58	58	58	58
R-squared	0.093	0.675	0.739	0.701

Standard errors of estimates are in parentheses. ***, **, * depict if the estimates are significantly different from 0 at 1%, 5%, and 10%, respectively. P-values of the estimates are in [ ]. Columns (2) – (4) also control for dummy variables for female, whether the student is an economics minor, missing GPA and missing prerequisite grade. Gender and economics minor dummies are insignificant in all models, while the significance of indicator variables for missing GPA and prerequisite grade vary.

Columns 3 and 4 illustrate interactions of year in college and prior GPA with post remote teaching semester, respectively. Column 3 shows that Seniors in Fall 2019 earn 0.553 points more relative to Sophomores, while Seniors in Fall 2021 earn 14.270 points less than Sophomores. The decline in OCS in the post remote teaching semester is led by Seniors – they earn almost 15 points lesser in Fall 2021, and the result is statistically significant. Column 4 shows that a higher GPA results in a lower decline in OCS – one point increase in prior GPA reduces the gap between Fall 2021 and Fall 2019 semesters by 8.657 points. The model predicts that a student with a GPA of 2.0 will earn 20 points lower in the post remote teaching semester relative to Fall 2019, while a student with a perfect GPA of 4.0 earns only 3 points lower.

Past papers estimate the changes in student outcomes during remote semesters relative to pre-pandemic in-person semesters and hence, are not directly comparable with this paper. However, I find that the estimate of the coefficient of Fall 2021 in Model 2 is similar to Course 3's effect in Orlov et al. (2021) but is higher than for the other courses presented in their paper. To make my estimate comparable, I standardize the final scores by means and standard deviations in the pre-pandemic semester, like in Orlov et al. (2021). These results are available upon request.

Conclusions and Discussions

This paper shows that the negative effects from the pandemic continued after the return to in-person teaching in this Econometrics class, thus hinting at a long tail of the pandemic and reiterating the call for additional student support (Gockley and Schneider, 2022). I also find that Seniors had the highest decline in scores illustrating that senioritis – described as the lack of motivation and focus that happens at the end of a particular event in a person's life (Lucietto et al., 2019) worsened after the pandemic. Lower prior GPA results in poorer performance in Fall 2021 consistent with past research that the pandemic was especially debilitating for students who were less prepared (Silva, 2024).

It is important to reiterate that the entire negative coefficient of the Fall 2021 dummy variable cannot be interpreted as the causal effect from the pandemic. The coefficient of Fall 2021 can be explained by the sum of all changes between the two points in time. These changes fall under three categories: i) changes related to the pandemic, ii) structural changes in the course that were put in place before the pandemic and are unrelated to the pandemic such as the introduction of discussion sessions, and iii) differences in student characteristics and other changes between the two years that are unrelated to the pandemic. However, it is highly likely that a large part of this negative effect is due to the pandemic and, in the absence of (ii), the negative effect may even be higher.

Additionally, students who consented to participate in this study are a self-selected group. No extra credit opportunities could be provided to students to participate, hence only 57% of the students signed the consent form. The average final score for the entire sample is lower than that of the consenting group. Hence, the magnitude and preciseness of the effect may change if all students were included.

It would have been very interesting if the study could continue into future semesters to see if the performance gaps that emerge due to the pandemic vanish. Unfortunately, changes in course curriculum and assessments in later semesters made comparisons with Fall 2019 untenable.

The data for this study comes from one class with a sample size of only 58 students. The results are not generalizable to other classes. This research can be extended by including different types of courses and students, which would increase the sample size and may reveal variations in the effect across different courses. Nevertheless, this study points towards a negative correlation

in OCS between pre and post pandemic semesters, and to the best of my knowledge is the first paper that uses economics courses.

Similar to Ferrer et al. (2023), by Fall 2021, students in my university would have witnessed two shocks to their learning – first, due to the sudden transition to remote learning and second, due to the readjustment back to in-person learning. The negative results presented in this paper are the cumulative effects from both these shocks. The learning decline during remote learning could be due to many external factors such as stress and isolation during the pandemic, additional responsibilities that students needed to assume such as caring for family members and lack of access to an adequate workspace and reliable internet connection, etc. Gestsdottir et al. (2021) find that students self-report worse mental and physical well-being during the pandemic, while Machado et al. (2024) observe a proportionally greater motivation decline among students with poor internet connection and for those who shared homes with more people and pets. Regarding the second shock, along with lesser knowledge retained from prerequisites taken during the pandemic, some other factors as noted in Kelly and Cuccolo (2024) could have contributed to a further decline - adjustments back to an in-person learning environment, taking in-person and closed book exams, depletion of time management and study skills due to remote learning, nervousness about social interactions, and COVID-19 safety concerns.

What could be done to counteract these negative effects? Some strategies that I have followed post pandemic include more flexibility with deadlines, providing access to class content outside of class by uploading class notes, offering a zoom option for office hours, allowing students to meet outside of officially scheduled office hours, if needed, rewarding class discussions and introducing group projects to encourage social interactions, and providing more guidance on how to optimally schedule their studying and assessments. These strategies are somewhat similar to the recommendations by Kelly and Cuccolo (2024). Teaching evaluations suggest that students appreciated the additionally flexibility and empathy.

Data Availability statement
The participants of this study did not give written consent for their data to be shared publicly, so the supporting data used in this study is not available.

Declaration of Funding
No funding was received.

Disclosure statement
No potential conflict of interest was reported by the author.

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