A random effects model for the impact of remote teaching on university students' performance

Un modello a effetti casuali per l'impatto della didattica a distanza sui risultati degli studenti universitari

Silvia Bacci and Bruno Bertaccini and Simone Del Sarto and Leonardo Grilli and Carla Rampichini

Abstract The COVID-19 pandemic had a relevant impact in all aspects of the social life. In Italy, in March 2020 schools and universities suspended the activities in presence and suddenly moved to remote teaching. In this contribution we aim at analysing the effects of remote teaching on university students' careers. To this end, we consider the differences in gained credits by the freshmen cohorts of academic years 2018/2019 and 2019/2020, enrolled in two bachelor degree courses (Business Administration and Psychology) at the University of Florence. Indeed, both cohorts regularly attended courses during the first semester, while only freshmen from academic year 2019/2020 experimented remote teaching during the second semester. As outcome, we consider the proportion of gained credits in the semester over the expected credits, thus the data have a panel structure with two observations per student. We estimate the impact of remote teaching through a random effects linear model. As a main result of our preliminary analysis, we detect a significant and negative effect of remote teaching on the career progressions of academic students.

Abstract *La pandemia da COVID-19 ha avuto un impatto rilevante su tutti gli aspetti della vita sociale. In Italia, nel marzo 2020 le scuole e le università hanno sospeso le attivià in presenza e hanno improvvisamente iniziato la didattica a distanza. In questo contributo ci proponiamo di analizzare gli effetti della didattica*

Silvia Bacci
Department of Statistics, Computer Science, Applications "G. Parenti" - University of Florence
e-mail: silvia.bacci@unifi.it

Bruno Bertaccini
Department of Statistics, Computer Science, Applications "G. Parenti" - University of Florence
e-mail: bruno.bertaccini@unifi.it

Simone Del Sarto
Department of Statistics, Computer Science, Applications "G. Parenti" - University of Florence
e-mail: simone.delsarto@unifi.it

Leonardo Grilli
Department of Statistics, Computer Science, Applications "G. Parenti" - University of Florence
e-mail: leonardo.grilli@unifi.it

Carla Rampichini
Department of Statistics, Computer Science, Applications "G. Parenti" - University of Florence
e-mail: carla.rampichini@unifi.it

a distanza sulle carriere degli studenti universitari. A tal fine, consideriamo le differenze nei crediti formativi acquisiti dalle coorti di immatricolati negli anni accademici 2018/2019 e 2019/2020, iscrittisi a due corsi di laurea triennale (Economia Aziendale e Psicologia) presso l'Università di Firenze. Infatti, entrambe le coorti hanno frequentato regolarmente i corsi durante il primo semestre, mentre i soli immatricolati della coorte 2019/2020 hanno sperimentato la didattica a distanza durante il secondo semestre. Come variabile di risposta consideriamo la proporzione di crediti acquisiti sui crediti attesi, per cui i dati hanno una struttura panel con due osservazioni per studente. Stimiamo l'impatto della didattica a distanza tramite un modello lineare a effetti casuali. Come risultato principale della nostra analisi preliminare, abbiamo individuato un effetto significativamente negativo della didattica a distanza sulle progressioni di carriera degli studenti universitari.

Key words: COVID-19, random effects model, repeated measures

1 Introduction

The COVID-19 pandemic manifested in Italy since February 2020, leading to disruptive effects on many aspects of people's social life. The suspension of the teaching activities in schools and universities was the first containment measure adopted by the Government to deal with the spread of the virus. Remote teaching has been the solution implemented by schools and universities to limit the damages to students' learning. In this contribution we aim at analysing the effects of remote teaching due to COVID-19 pandemic on the university students' careers. There is a growing literature on this topic (e.g., [2]), but we are not aware of systematic studies on the impact in terms of gained credits.

We compare the cohorts of freshmen of academic years 2018/2019 and 2019/2020 enrolled in the bachelor degree courses in Business Administration and Psychology at the University of Florence. Teaching activities were regular for the cohort 2018 along all its first academic year (first semester September-December 2018 and second semester February-June 2019), whereas the cohort 2019 attended regular lessons only during the first semester (September-December 2019) and experimented the remote teaching during second semester (February-June 2020). To evaluate the impact of remote teaching, we compare the number of credits (ECTS) gained during the second semester by these two cohorts, using information from the first semester to remove a possible "cohort effect" not depending on the remote teaching.

The remaining part of the paper is organised as follows. In Section 2 we describe the data and in Section 3 we illustrate results obtained by preliminary analyses. Final remarks are reported in Section 4.

Table 1 Descriptive statistics of freshmen by degree courses (BA: Business Administration; PSY: Psychology) and year of enrolment (2018 and 2019): number of enrolled students (*N*), % of female, average high school (HS) grade (standard deviation within parentheses) and type of high school

	BA			PSY		
	2018	2019	Total	2018	2019	Total
N	640	668	1,308	427	429	856
% female	42.3	42.4	42.4	72.8	79.0	75.9
HS grade	78.1	76.6	77.3	80.6	79.2	79.9
	(11.6)	(11.4)	(11.5)	(10.7)	(11.2)	(11.0)
Type of HS (%)						
Scientific	30.8	33.1	32.0	36.3	32.6	34.5
Technical	39.8	36.2	38.0	8.4	16.1	12.3
Vocational	8.0	6.4	7.2	4.7	1.9	3.3
Humanities	18.6	13.6	16.1	42.9	38.7	40.8
Other	2.8	10.7	6.7	7.7	10.7	9.2

2 Data

We consider data obtained from the administrative archive on students' careers, which includes some background characteristics, such as sex, high school (HS) type and grade, and information on passed exams. Specifically, we focus on two cohorts of freshmen enrolled in academic years 2018/2019 and 2019/2020 in the bachelor degree courses in Business Administration (BA) and Psychology (PSY) at the University of Florence. The dataset includes 2,164 students (about 60% in BA and 40% in PSY) whose characteristics are summarised in Table 1.

By inspecting the table, we notice a prevalence of male students in BA (57.6%), whereas female students are definitely more frequent in PSY (75.9%). Moreover, HS grade is on average slightly greater in freshmen of PSY with respect to their peers of BA. As far as the composition in terms of HS type is concerned, almost three students of PSY out of four come from scientific and humanities high schools (i.e., "licei"), while in the BA degree program we can observe a predominance of students from scientific and technical schools. Within each degree course, the two cohorts have similar characteristics, though in PSY we notice an increase of the female share (+6.2% in 2019) and the HS type composition, where a decrease in students from humanities and scientific high schools occurs in favour of technical schools or other type.

In order to study the effect of remote teaching on students' performance, we consider the proportion of credits (ECTS) gained in each semester out of the total of planned credits envisaged by the degree course. We can disentangle this effect by comparing students' performance in the two cohorts. In fact, for the exams taken in the first semester session, none of the two cohorts have experienced remote teaching, while a potential effect can be highlighted for exams taken by the cohort 2019 during the second semester session (i.e., in June, July and September 2020).

Table 2 Average proportion of credits gained by students of BA and PSY by semester and cohort

	BA		PSY	
Semester	2018	2019	2018	2019
First	0.395	0.513	0.593	0.623
Second	0.564	0.607	0.856	0.810

The first year degree course in BA envisages three 9-credit exams in both semesters (hence 27 credits in each one), while PSY freshmen have to face three exams in the first semester (27 credits) and four in the second one (30 credits). Students' performance are summarised in Table 2 in terms of average proportion of gained credits out of the total credits envisaged by the degree course. Note that these proportions may theoretically be higher than one, whenever a student completes the exams of the first year and takes in advance exams of the second year (in practice, this is a rare instance).

Looking at Table 2, we observe that the performance of students in the second semester is higher than their performance in the first semester, in particular for PSY. Moreover, in the first semester the cohort 2019 reports a better performance with respect to cohort 2018. This is especially true for freshmen of BA, where the proportion of gained credits raises from 0.395 to 0.513. A likely reason for this trend is a structural change in the study plan of BA: in the first academic year, the cohort 2018 had Private Law, whereas the cohort 2019 had Public Law.

As concerns the second semester, results differ for the two degree courses. Credits gained by BA students tend to increase (proportions from 0.564 to 0.607 on average), whereas credits gained by PSY students decrease (proportions from 0.856 to 0.810 on average).

3 Estimating the impact of remote teaching

To estimate the impact of remote teaching, we fit a linear random effects model for repeated measures [3], separately for students of the two degree courses (BA and PSY). The outcome Y_{it} is the proportion of credits gained by student i in semester t over the expected credits, with $i = 1, \ldots, n_d$ (where index d refers to the degree course) and $t = 0$ for the first semester and $t = 1$ for the second semester. The model is formulated as

$$Y_{it} = \alpha + x_i'\beta + \gamma_1 c_i + \gamma_2 t + \delta(c_i \times t) + u_i + \varepsilon_{it},$$

where x_i is a vector of student characteristics (Female, HS grade, and HS type), c_i is a dummy variable for the cohort of student i (reference: 2018) and t is a dummy variable for the semester (reference: first semester). The random effect u_i for student i collects unobserved factors at student level and is assumed to follow a Normal distribution with mean 0 and variance σ_u^2, whereas the residual error ε_{it} (indepen-

1478

dent of u_i) is assumed to follow a Normal distribution with mean 0 and variance σ_ε^2. The parameter of main interest is δ, namely the coefficient of the interaction between cohort c_i and semester t, which represents the effect of remote teaching after controlling for the structural differences in the cohorts and the semesters. This is a difference-in-differences approach [1] where the second semester is the post-treatment period and the cohort 2018 is the control group.

Results of fitted models are displayed in Table 3(a) for BA and in Table 3(b) for PSY. The HS grade and the HS type have similar effects in the two degree courses: students with higher HS grades and, most of all, coming from a scientific HS progress in the academic career faster than their peers. On the opposite, differences between females and males depend on the degree course: no significant difference is observed for BA, whereas male students of PSY perform significantly worse than their female colleagues.

As for the cohort effect γ_1, the two cohorts of BA students are significantly different, with students of cohort 2019 performing better than colleagues of cohort 2018. This result confirms the presence of structural differences between the programs of BA in the two academic years. On the opposite, no significant difference is detected between the two cohorts of PSY freshmen.

For what concerns the semester effect γ_2, students of the cohort 2018 perform significantly better in the second semester with respect to the first one (regression coefficient equals 0.169 for BA and 0.264 for PSY).

Finally, the estimated effect of remote teaching δ, associated to the interaction between semester and cohort, is nearly equal for the two degree courses: the experience of remote teaching caused a statistically significant slowdown in the students' career progression, with estimated regression coefficient equal to -0.075 for BA and -0.077 for PSY. These values are changes in the proportion of gained credits over expected credits: in absolute terms, they correspond to a reduction of about 2 credits.

4 Conclusions

The preliminary results point out a negative impact of remote teaching on the productivity of students in Business Administration and Psychology. The analyses will be further developed in order to take into account the following issues. First, we intend to formulate a model that accounts in a suitable way the specific nature of the response variable, that is, a proportion with possible values greater than one and with excess of zeros (i.e., students that do not take any exam). Second, we will extend the analysis to other bachelor and master degree courses to investigate the existence of differences among academic schools in the implementation of remote teaching. In order to investigate the impact of remote teaching on specific exams, a promising route is to formulate a multilevel model with pseudo-panel data, with students as first-level units and exams as second-level units observed for two academic years. Third, we intend to incorporate teaching evaluations by students in the analysis. Since questionnaires are anonymous, the evaluations have to be aggregated at course level.

Table 3 Regression model estimates for students of BA (a) and PSY (b). Note: the 95% confidence intervals (95% CI) for variance components are computed with 500 bootstrap replications

(a)

	Estimate	Std. Error	*p*-value	
Intercept	0.299	0.028	< 0.001	***
Male (ref. Female)	-0.003	0.019	0.889	
HS grade	0.013	0.001	< 0.001	***
HS type (ref. Scientific)				
Humanities	-0.191	0.028	< 0.001	***
Vocational	-0.408	0.037	< 0.001	***
Technical	-0.177	0.022	< 0.001	***
Other	-0.147	0.038	< 0.001	***
Cohort 2018 (ref. 2019)	0.127	0.021	< 0.001	***
Second Semester (ref. First)	0.169	0.015	< 0.001	***
Interaction (cohort, semester)	-0.075	0.021	< 0.001	***
σ_u^2	0.069 (95% CI: 0.061–0.079)			
σ_ε^2	0.071 (95% CI: 0.065–0.077)			

(b)

	Estimate	Std. Error	*p*-value	
Intercept	0.513	0.034	< 0.001	***
Male (ref. Female)	-0.108	0.028	< 0.001	***
HS grade	0.008	0.001	< 0.001	***
HS type (ref. Scientific)				
Humanities	-0.127	0.042	0.003	**
Vocational	-0.083	0.027	0.002	**
Technical	-0.249	0.066	< 0.001	***
Other	-0.082	0.038	0.034	*
Cohort 2019 (ref. 2018)	0.036	0.028	0.202	
Second Semester (ref. First)	0.264	0.022	< 0.001	***
Interaction (cohort, semester)	-0.077	0.031	0.013	*
σ_u^2	0.059 (95% CI: 0.049–0.072)			
σ_ε^2	0.102 (95% CI: 0.092–0.112)			

References

1. Abadie A.: Difference-in-Difference Estimators. In: Palgrave Macmillan (eds.) The New Palgrave Dictionary of Economics. Palgrave Macmillan, London (2008)
2. Aucejo, E. M., French, J., Ugalde Araya, M. P., Zafar, B.: The Impact of COVID-19 on Student Experiences and Expectations: Evidence from a Survey. J. Public Econ. **191**, 104271 (2020)
3. Hedeker, D., Gibbons, R.D.: Longitudinal Data Analysis. Second edition. Wiley (2021)