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DISCUSSION PAPER SERIES

IZA DP No. 17173

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ABSTRACT

Every Cloud Has a Silver Lining: The Role of Study Time and Class Recordings on University Students' Performance during COVID-19

We study the impact of the COVID-19 pandemic and its side effects on the academic achievement of students in a large university located in a northern Italian region severely affected by the pandemic. Thanks to the richness of our data, we can investigate for the first time the role of two specific channels: the increase in study time due to the exceptionally strict confinement measures adopted and the availability of class recordings. We use administrative data on four cohorts of students merged with original survey data. We adopt a fixed-effect difference-in-differences approach, where we compare the outcomes of students from different enrolment cohorts observed in the same semester of their academic career before and after the COVID-19 outbreak. We find a generalized positive effect of the COVID-19 pandemic on students' academic achievement in terms of both earned credits and GPA. We provide evidence that both increased study time and the availability of class recordings contributed to mediating this positive effect.

JEL Classification: I23, I24
Keywords: COVID-19, university education, distance learning, study time

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1. Introduction

The education system worldwide was profoundly affected by the COVID-19 pandemic at every stage, from primary to tertiary education. At the university level, academic institutions were forced to quickly move all classes and degree programs online. In addition to the difficulty of adapting in a short time to new learning and assessment methods and to the sudden lack of interactions with teachers and peers, general worries related to the unpredictable unfolding of the pandemic and prolonged lockdowns and social distancing contributed to the deterioration of students' mental health (Browning et al. 2021; Hawke et al. 2021; Ihm et al. 2021; Jaeger et al. 2021; Kauhanen et al. 2022), further challenging their learning process. At the same time, the pandemic outbreak led, in some cases, to direct health effects for students and faculty, possibly slowing the pace of studying and teaching.

On the other hand, the time potentially available for studying increased due to the social distancing policies implemented to reduce the spread of COVID-19 that led to the closure of recreational and sports facilities, limiting access to leisure activities. The severity of these restrictions varied across countries and regions, but, in general, students suddenly gained a large amount of additional time to focus on their studies. In addition, the recordings of classes and lectures often made available for students during the pandemic period increased the flexibility of the learning process, as students could listen to lectures asynchronously according to their own pace and with an unlimited possibility to revisit them.

Overall, the multifaceted consequences of the pandemic have greatly affected several aspects of university students' lives, but the direction of its effect on academic achievement is ambiguous. On the one hand, isolation, psychological and physical health problems, and the difficulty in adapting to the new learning environment could have negatively affected academic achievement; on the other hand, increased time to study and availability of recorded classes could have positively affected it.

This paper investigates the impact of the COVID-19 pandemic and its side effects on the academic performance of university students in Italy.[1] In addition, thanks to the richness of our data, we can look into the black box of COVID-19 and document for the first time the contribution of two specific channels: increased study time and availability of recorded classes.

We use rich longitudinal administrative data covering the universe of students enrolled in the four academic years from 2016-17 to 2019-20 at the University of Milano-Bicocca (UNIMIB). The UNIMIB is a major multidisciplinary public university of a significant size located in Milan, in the heart of Lombardy, a large region in northern Italy. Italy was the first country severely affected by the COVID-19 pandemic after China and, within Italy, Lombardy was the most severely affected region. In addition to the administrative data, we fielded an original survey instrument through which we gathered rich information on students, including their experience with online teaching.

[1] Hereafter in this paper, by the COVID-19 pandemic, we refer not only to the associated health problems but to all its implications and side effects, including more online teaching and restrictions in the lives of students.

A recent growing body of literature has analysed the impact of the COVID-19 pandemic on educational outcomes. While this literature tends to agree on the negative effect of the pandemic on pre-university students' performance (see Engzell, Frey, and Verhagen 2021; Werner and Woessmann, 2021; Agostinelli et al. 2022; Maldonado and De Witte 2022), the evidence on tertiary education is mixed, and the results depend on the specific outcomes and the contextual conditions considered. For the US, Aucejo et al. (2020) find that during the COVID-19 pandemic, students studied less and were more likely to delay graduation and withdraw from classes. Orlov et al. (2021) find that total assessment scores declined in seven intermediate economics courses. Nevertheless, the negative effect is mitigated by prior online teaching experience and teaching methods encouraging active engagement. Bulman and Fairlie (2021) find that while enrolment dropped precipitously and course completion slightly fell, failure rates decreased substantially during the pandemic period in the California Community College System. Rodriguez-Planas (2022a, 2022b) finds that GPAs were higher, and there was no effect on credits earned during the spring semester at Queens College in New York City. For Spain, Gonzales et al. (2020) find a significant positive impact of the COVID-19 pandemic on university students' performance that they relate to a change in learning strategies.

Some studies have investigated the immediate effect of the COVID-19 pandemic on the educational outcomes of Italian university students, focusing on the first pandemic wave in the Spring of 2020. Again, the empirical evidence is mixed, and the results vary depending on the context and outcomes considered. Casalone et al. (2021) focus on a university located in Piedmont, a large northern Italian region, and find no negative effect of the pandemic on the probability of passing the exams, which they attribute to the restrictive lockdown measures applied. Bratti and Lippo (2022) use administrative data from the University of Milano and find a generalized positive effect on GPA and a negative effect on the number of credits earned by boys but no impact on girls. Bonaccolto-Topfer and Castagnetti (2021) focus on a large public university in Lombardy and find a significant positive effect of the pandemic on GPA. The only paper based on data from a southern Italy university is De Paola et al. (2022), who find that online teaching in the first wave of the pandemic slightly reduced the number of earned credits.

Our paper adds to this literature in different ways. First, unlike most studies on the effect of COVID-19 on university students that document only the overall impact of the pandemic, we investigate for the first time two important transmission mechanisms: study time and availability of recorded classes. This allows us to draw some policy implications in a more general non pandemic setting. Second, we look at the impact of COVID-19 one year after the start of the pandemic, using data on both the spring 2020 and the fall 2020 pandemic waves. The longer period considered allows for a more comprehensive evaluation of the adaptation process to the new online teaching and learning approaches after the sudden and unexpected shock of the initial pandemic months. Finally, thanks to our detailed survey data, we can explore the heterogeneity of the results along several dimensions.

Our empirical strategy exploits the fact that the year of enrolment differentially exposed students to the COVID-19 pandemic at different stages of their university careers. The Italian university system is relatively rigid, and in each academic year the study plan of each semester tends to be stable over time. This implies that the semesters affected by the pandemic (treated semesters) have the same educational content as those in prepandemic years. We exploit this feature of the Italian university system and adopt a fixed effect difference-in-difference approach, comparing the outcomes of students from different enrolment cohorts observed in the same semester of their academic career before and after the COVID-19 outbreak.

We find a positive and significant impact of the COVID-19 pandemic on different students' outcomes. On average, the number of credits earned in each semester increased by 1.4, which corresponds to a 7 percent increase. Moreover, we find a slight reduction of approximately one percentage point in inactivity, measured as the probability of not gaining any credits in a given semester, and a small positive impact of COVID-19 on GPA.

We explore two different channels that may have transmitted the positive effect of the COVID-19 pandemic on academic achievement. The first is related to the increase in the time available for studying. In Italy, at the spread of the pandemic in February 2020, the national government declared a state of emergency, and on March 8th, a government decree drastically restricted the movement of people. The implementation of confinement measures was particularly rigorous, and there was no chance for performing any leisure or sports activities outside. Substitution of leisure activities with studying may have taken place, resulting in improved academic performance. In this respect, the COVID-19 pandemic can be considered an exogenous shock affecting the time potentially available for studying. To explore the study time mechanism, we use survey data on students' study hours. The data show that most students studied more hours compared to the prepandemic period, and our estimates indicate that the positive effect of the COVID-19 pandemic is larger for the students who increased their study time the most. To the best of our knowledge, this is the first paper documenting the role of increased study time on academic achievement during the pandemic. This result is consistent with the economic literature showing that study time is a key input of the education production function (Stinebrickner and Stinebrickner, 2004, 2008; Jürges and Khanan, 2021).

A second channel that has the potential to mediate the positive effect of the COVID-19 pandemic is related to the opportunity for students to listen to the lectures' recordings at their preferred time and as many times as they liked when the implementation of online teaching included the availability of class recordings, as it was the case at the UNIMIB. We provide evidence in favour of this mechanism using survey information on students' perceptions regarding how lesson recordings improved their possibility of attending classes; we show that the positive impact of the COVID-19 pandemic is significant only for students who thought that the availability of class recordings facilitated their access to lectures.

We conduct a heterogeneity analysis, and we find that our main result of a positive effect of the COVID-19 pandemic does not differ across students with different socioeconomic backgrounds, suggesting that achievement disparities between advantaged and disadvantaged students did not widen during the pandemic. Also, we do not detect any significant heterogeneity by baseline ability (i.e., high school final grade), type of high school, working status, or severity of the pandemic at the municipal level, which suggests that our results are not affected by direct health effects.

The paper proceeds as follows. Section 2 describes the institutional background. Section 3 describes the data. Section 4 presents the empirical methodology. Section 5 presents our results: the main results are reported and discussed in Section 5.1; in Section 5.2, we investigate the potential transmission channels; Section 5.3 shows the heterogeneity analysis. We present several robustness checks in Section 6 and some concluding remarks and discussion in Section 7.

2. Institutional background

In Italy, tertiary education is mainly provided by public universities. The Italian university system is organized in three cycles: a three-year bachelor's degree (*Laurea*), a two-year master's degree (*Laurea Magistrale*), and a three- to four-year Ph.D. program (*Dottorato di Ricerca*).[2] At the bachelor's and master's degree levels, university programs are structured in credits (CFU, *crediti formativi universitari* or university training credits). A university credit is equivalent to 25 hours of workload, including attending classes and individual study time. The average academic workload a full-time student performs in one year is, by convention, measured as 60 CFUs. It follows that the bachelor's and master's degrees are awarded to students who have gained, respectively, 180 and 120 credits. Students earn most credits by passing the exams of the courses included in their study plan; in some cases, a limited number of credits can be earned by carrying out activities such as internships.

The grading system works on a 0-30 scale, with 18 being the lowest passing grade and 30 the highest. To reward exceptional performance, a distinction (*lode*) can be assigned, and the grade is registered as 30 *cum laude,* which we convert to 31 in the empirical analysis.

Our analysis is based on a large public university, the University of Milan-Bicocca (UNIMIB), which is located in Lombardy, the Italian region that was most severely hit by the COVID-19 pandemic. Approximately 34 thousand students are enrolled at UNIMIB in 68 bachelor and master programs covering seven main subject areas: Economics and Statistics, Educational Sciences, Law, Medicine and Surgery, Psychology, Sciences, and Sociology.

[2] There is a limited number of single-cycle degree programs (one-block courses) organized in one block of either five years (architecture, law, pharmaceutical chemistry and technology, pharmacy, primary teacher education and veterinary medicine) or six years (dentistry and medicine), which we do not include in our analysis.

All students of a given degree program have the same study plan, strictly setting the number of credits that they have to earn in each academic year and a large set of predetermined courses. The number of elective courses is very low, and they have to be chosen by students well in advance, generally during the previous academic year.[3] For each academic year, the study plan and the courses' distribution between semesters are defined by a collegial document approved within February of the previous academic year. The study plan changes only marginally from one year to the next.

At the UNIMIB, the academic year starts at the beginning of October, and teaching is organized into two semesters: the first semester starts at the beginning of October and ends in mid-January; the second semester starts at the beginning of March and ends in mid-June. There are two main exam sessions, each including at least two exam rounds: one in the winter, between the end of the first teaching semester and the beginning of the second, and one in the summer, between the end of the second teaching semester and the beginning of the first semester of the next academic year. The UNIMIB rules provide that each course has at least five exam rounds throughout the year. In case of failure, students can retake exams with no limits.

During the outbreak of the pandemic, the UNIMIB governance requested that all instructors record their classes and leave them posted on the course website up to the third exam round after the end of course delivery (which approximately corresponds to six months). Then, since the beginning of the first pandemic semester (i.e., spring 2020), students could easily access recordings of all classes for a long period after the end of the teaching semester.

In the same period, the UNIMIB guidelines recommended administering exams orally, at least in part. In case of a written assessment, exam integrity was secured by the adoption of two custom browsers (LockDown Browser and Proctorio), locking down the testing environment within a learning management system. For instance, browser menu and toolbar options were removed, access to other applications, copying and pasting to or from an assessment were prevented, and printing and screen capture functions were disabled. During the exam, both the environment video and audio were recorded, and in the event of any suspected cheating (e.g., an abnormal noise or the presence of persons different from the student in the room), a red light was turned on, and the instructor was required to review the recording and eventually ask the student to retake the exam orally. Students were aware of the monitoring system. In addition, teachers were also encouraged to ask students to enter the videoconferencing room with their smartphones and to turn on the camera to capture themselves and their computer screen from behind. In this way, teachers were able to monitor students directly during the exams, which has been shown to significantly reduce the risk of online cheating (see Bilen and Matros, 2021).

[3] This implies that students in our sample period chose their electives before the pandemic.

3. Data

Our empirical analysis is based on two different data sources: an administrative dataset (ADMIN from now on) and an original survey dataset (UNDER UNIMIB Distance Learning Dataset). We were able to merge the two datasets using an anonymous student identifier.

The ADMIN administrative dataset covers the universe of students enrolled at UNIMIB in the four academic years from 2016-17 to 2019-20, corresponding to approximately 128,000 observations for approximately 57,000 students. The data report information on students' sociodemographic characteristics, namely, age, gender, city of birth and city of residence, and an indicator of family income (the Equivalent Economic Status Indicator, ISEE), and on their baseline achievement (final grade obtained in the national examination at the end of high school for bachelor's students and final grade obtained at the end of the bachelor's degree for master's students). In addition, these data contain detailed information on students' entire university careers up to the end of March 2021 (i.e., the end of the winter exam session of the 2020-21 academic year), including the date on which they passed each exam and the number of credits and the grade awarded in each exam.

The UNDER data were collected through an original survey instrument administered online using the *Limesurvey* tool.[4] The survey was administered between the end of the first teaching semester of the 2020-21 academic year and the beginning of the 2021 winter exam session (i.e., between the end of December 2020 and the beginning of January 2021) to all the students enrolled at UNIMIB in the 2020-21 academic year. Students received an initial e-mail notification with an embedded survey link, and the initial e-mail was followed by three weekly reminder e-mails to nonrespondents. The response rate was exceptionally high: 16,751 students completed the questionnaire (corresponding to a response rate of approximately 50%). The survey collected rich information on students' demographic characteristics, socioeconomic background, place of residence, high school type, final grade, weekly study time, working status, and detailed opinions on distance learning. We will exploit this rich set of information to investigate the channels through which the COVID-19 pandemic affected academic performance and the presence of heterogeneous treatment effects.

4. Methodology

[4] The survey was approved by the UNIMIB ethics committee on July 9th 2020.

In this section, we describe the identification strategy and the econometric specification, and we present descriptive statistics.

4.1 Identification strategy and sample selection

To estimate the effect of the COVID-19 pandemic on university students' outcomes, we exploit the events that happened in Italy during the pandemic period. The first COVID-19 lockdown started in early March 2020, coinciding with the beginning of the UNIMIB spring semester. At the same time, all university courses and exams moved online. By the beginning of the following academic year, in October 2020, an attempt was made to return to a minimum level of in-person attendance for freshmen by allowing them to attend courses in-person one week every four on a voluntary basis, but a second pandemic wave hit Italy at the beginning of November. Lombardy returned to strict lockdown, and all universities switched once again completely to online teaching. Therefore, in the time period covered by our data, two COVID-19 waves hit two consecutive academic semesters: the spring semester of the 2019–20 academic year and the fall semester of the 2020–21 academic year.

As mentioned in Section 2, the Italian university system is very rigid: the study plan for each year in every degree program has a large set of predetermined courses with very few elective courses, and in general, it does not change from year to year. At the UNIMIB, teaching is organized in two semesters per year, for a total of six semesters for bachelor's students and four semesters for master's students. The courses provided in each semester of each academic year are generally the same. We can thus assume that all the students' cohorts that we consider in our analysis had to pass the same set of exams in a given semester of their academic career, regardless of whether the semester was before or during the pandemic. In view of this, with our empirical strategy, we compare the outcomes of students from different enrolment cohorts observed in the same semester of their academic career (from semester 1 to 6 for bachelor's students and from semester 1 to 4 for master's students) before and after the COVID-19 outbreak.

To perform our empirical analysis, we work with two samples: the ADMIN sample, which includes data for all the students in all the available cohorts, and the ADMIN/UNDER sample, which considers only the students who responded to the survey.

Panel A in Figure 1 shows our comparison groups for bachelor's students in the ADMIN sample. The 2016 cohort includes students who completed their academic career before the COVID-19 pandemic (never treated cohort). The 2017 to 2019 cohorts completed a part of their academic career before the pandemic and a part during the pandemic (treated cohorts). Specifically, the 2017 cohort completed their last semester (the sixth) during the pandemic; the 2018 cohort their fourth and fifth semester; and the 2019 cohort their second and third semester. The treatment (i.e., the pandemic) is then staggered across semesters of students' academic careers.

We compare the performance of students treated in a specific semester with that of students not treated in the same semester. To illustrate, we compare the performance in the sixth semester of the 2017 cohort with the performance in the sixth semester of the 2016 cohort; we compare the performance in the fourth and fifth semesters of the 2018 cohort with the performance in the fourth and fifth semester of the 2016 and 2017 cohorts; and we compare the performance in the second and third semesters of the 2019 cohort with the performance in the second and third semester of the 2016, 2017 and 2018 cohorts.

Figure 1. Identification strategy

Panel A: ADMIN sample (bachelor's degree students)

	2016/2017		2017/2018		2018/2019		2019/2020		2020/2021
	1st term	2nd term	1st term	2nd term	1st term	2nd term	1st term	2nd term	1st term
Enrolment cohort									
2016	1st semester	2nd semester	3rd semester	4th semester	5th semester	6th semester			
2017			1st semester	2nd semester	3rd semester	4th semester	5th semester	6th semester	
2018					1st semester	2nd semester	3rd semester	4th semester	5th semester
2019							1st semester	2nd semester	3rd semester

COVID-19

Panel B: UNDER/ADMIN sample (bachelor's degree students)

	2018/2019		2019/2020		2020/2021
	1st term	2nd term	1st term	2nd term	1st term
Enrolment cohort					
2018	1st semester	2nd semester	3rd semester	4th semester	5th semester
2019			1st semester	2nd semester	3rd semester

COVID-19

UNDER SURVEY

Notes: Treated semesters are in the coloured boxes.

Panel B in Figure 1 shows the comparison groups for bachelor's students in the UNDER/ADMIN matched database. In this case, the sample includes students participating in the UNDER survey, i.e., those who were enrolled at UNIMIB in the 2020-21 academic year. This means that it includes only

students of the 2018 and 2019 cohorts because the previous cohorts had ended their academic careers and were no longer enrolled in the 2020-21 academic year.[5]

For master's degree students, we rely only on the ADMIN sample because in the ADMIN/UNDER sample, we observe only one treated cohort (enrolled in 2019 and hit by the pandemic in the second and third semesters), while the previous cohorts had already finished their academic careers in the 2020-21 academic year; therefore, we have no control group. Focusing on the ADMIN sample, we compare the performance in the fourth semester of the 2018 cohort with the performance in the same semester of the 2016 and 2017 cohorts; the performance in the second and third semesters of the 2019 cohort with the performance in the second and third semesters of the 2016, 2017 and 2018 cohorts.[6]

Table 1 reports some descriptive statistics of the main variables used in the empirical analysis for the two samples. The first column refers to all bachelor's and master's students in the four cohorts included in the ADMIN sample, while the second column refers to bachelor's students in the merged UNDER/ADMIN sample discussed above.

The average number of credits earned in each semester is 19.5 for all students in the administrative data and 21.4 for the UNDER/ADMIN sample, which suggests that students in the latter sample tend to be slightly better in terms of academic performance.[7] This is also evident from their lower inactivity rates (6 percent versus 17 percent in administrative data), while the GPA is almost identical in the two samples. Females tend to be overrepresented in the UNDER/ADMIN sample (66 percent versus 59 percent). The other variables are similar across the samples and indicate that the survey data are highly comparable and aligned with the administrative data.

Survey data in column 2 show that approximately 1 out of 5 students is a working student, over 30 percent have a low educational background (neither parent is a college graduate), and 69 percent come from an academic high school.[8]

[5] The data include some students from previous cohorts but we exclude them from the sample because we exclude students enrolled beyond the official duration of the study program.

[6] The figure illustrating the identification strategy for master students is in Figure A1 in the Appendix.

[7] While students are expected to earn approximately 30 credits per semester (see Section 2), the students in our samples obtain approximately 20 credits on average over a semester, which is typical of the Italian university system, where students frequently take more time than expected to graduate (see also De Paola et al., 2023).

[8] In Italy, there are three main high school tracks: *liceo*, the academic track, where the education provided is advanced and mainly theoretical, *istituti tecnici*, that provide both a theoretical education and a specialization that depends on the subtrack (economic or technological), and *istituti professionali*, that offer vocational training oriented towards different practical subjects in either the services or industry/craft sector.

Table 1. Descriptive statistics

	(1) ADMIN sample	(2) ADMIN/UNDER
Total semester credits	19.51	21.39
	(13.95)	(11.45)
GPA	26.11	25.78
	(2.89)	(2.77)
Inactive	0.17	0.06
	(0.37)	(0.24)
Bachelor degree	0.69	1.00
	(0.46)	(0.00)
Master degree	0.31	0.00
	(0.46)	(0.00)
Female	0.59	0.66
	(0.49)	(0.47)
Family income	28901	29599
	(33,433)	(23,157)
Final high school grade	77.75	81.21
	(11.25)	(11.63)
Excess mortality	12.55	12.21
	(14.12)	(14.33)
Field of study		
Economics and statistics	0.25	0.25
	(0.43)	(0.43)
Educational Sciences	0.16	0.13
	(0.37)	(0.34)
Law	0.04	0.05
	(0.2)	(0.21)
Medicine and Surgery	0.05	0.08
	(0.23)	(0.27)
Psychology	0.12	0.12
	(0.32)	(0.32)
Sciences	0.25	0.26
	(0.43)	(0.44)
Sociology	0.12	0.12
	(0.33)	(0.32)
UNDER/ADMIN variables		
Weekly study time	-	24.19
		(12.57)
Working student	-	0.18
		(0.38)
Academic high school	-	0.69
		(0.46)
First-generation college degree	-	0.32
		(0.46)
N	139,924	17,202

Notes: The table shows, for each variable, the mean and the standard deviation in parentheses. The total number of observations for GPA is 112,747 for the ADMIN sample in column 1 and 15,681 for the UNDER/ADMIN sample in column 2 due to students not passing exams. The total number of observations for income is 109,545 for the ADMIN sample in column 1 and 14,074 for the UNDER/ADMIN sample in column 2 due to missing observations. The final high school grade is available only for bachelor's students. Excess mortality is the percentage increase in the number of deaths observed in 2020 with respect to the previous four years in the municipality of residence. First generation college degree is a dummy taking the value of one for students without any parent with a college degree.

4.2 Econometric model

To estimate the effect of the pandemic on students' achievement, we estimate the following equation using a two-way fixed-effect (TWFE) approach:

$$Y_{ics} = \alpha + \beta\ Treated_{ic} \times Pandemic_{cs} + \mu_i + \tau_s + \sum_c \rho_c S_s + \varepsilon_{ics} \quad (1)$$

where the suffix "*ics*" denotes the *i-th* individual in enrolment cohort *c* observed in semester *s*. Y_{ics} denotes one of three university students' outcomes: *i*) the total number of credits earned in a given semester; *ii*) inactivity status (a dummy variable equal to 1 if the student has not gained any credit in a given semester); *iii*) GPA, which is calculated as the average of all the grades obtained in the passed exams in the semester weighted by the credits awarded in each exam. μ_i is a vector of individual fixed effects, and τ_s is a semester fixed effect to control for the specific semester in which students are observed. $Treated_{ic}$ is a dummy variable indicating the treated cohorts, while $Pandemic_{cs}$ is a dummy variable that takes value one for the treated (pandemic) semesters of each cohort. The coefficient of this interaction semester computes the difference in the within-student demeaned outcomes within the same semester between the treated (affected by the COVID-19 pandemic) and control students. The latter are either the cohorts not affected by the COVID-19 pandemic or the treated students observed in their pretreatment semesters (see Section 4.1). β is our parameter of interest, since it measures the impact of the COVID-19 pandemic on students' outcomes.

Individual-specific fixed-effects control for observed and unobserved students' time-invariant characteristics, such as gender and parental background. Because students who change degree programs are excluded from our sample, individual fixed effects also absorb the constant-over-time characteristics of each degree program and field of study. Finally, and more importantly, individual fixed effects also control for constant over-time characteristics of different enrolment cohorts.

A set of cohort-specific semester trends accounts for cohort characteristics that are not constant over years of enrolment. These trends are not included when we estimate equation (1) on the UNDER/ADMIN sample, where we have only three semesters by two cohorts, because the model would become overidentified.[9]

Semester-specific fixed effects transform the model in a within-semester estimation and control for any common shock happening in a given semester and the difference in acquired credits between semesters. The potential confounding effect of time-varying differences in course organization and in the exams required in each degree program will be assessed by including program degrees' trends in the robustness section.

[9] The estimation of equation (1) with the restricted UNDER/ADMIN sample is computationally similar to a standard fixed-effect differences-in-differences, in which the dummy pandemic (post) is included together with the interaction between treated and pandemic (post).

Given our specification and identification strategy, the main assumption that we have to make to interpret β as a causal effect is that, absent the COVID-19 pandemic, the treated semesters would have been largely identical to the same semesters in prepandemic years (after controlling for observable and unobservable time-invariant effects). In Section 6, we perform several robustness checks of the baseline results.

An important concern related to the use of a TWFE estimator with the ADMIN sample is that when the timing of the treatment (the semester in our case) varies among subjects, i.e., it is staggered, and the effect increases with exposure, the TWFE estimator computes a weighted average of all possible two by two differences-in-differences estimates in the data (de Chaisemartin and D'Haultfoeuille, 2020; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021). We will address this issue empirically in the robustness section by following Sun and Abraham (2021) and adopting an event-study specification to test for dynamic effects. We will also follow Callaway and Sant'Anna (2021) and re-estimate our model by applying a suitable set of weights to correct for the relative importance of each two-by-two differences-in-differences.

5. Results

In this section, we present the estimation results. First, we show the results of our baseline specification for different outcomes and samples (section 4.1). Then, in Section 4.2, we discuss possible transmission channels of the main effect. In Section 4.3, we estimate heterogeneous treatment effects by exploiting the rich set of information available in our data.

5.1 Baseline results

Table 2 reports the results of the main specification where we estimate equation (1) on the full ADMIN sample for bachelor's and master's students (column 1) and on the UNDER/ADMIN sample for bachelor's students (column 2). To check whether the results obtained in the two datasets are comparable, in Table A1 in the Appendix we replicate the estimation on the ADMIN dataset for bachelor's students on the same cohorts used for the analysis in the UNDER/ADMIN dataset.

The dependent variables are the total number of credits earned by semester (panel A), a dummy variable indicating whether a student is inactive (no credits earned) in a given semester (panel B), and the semester's GPA (panel C). For each specification, we report the coefficient of the interaction term between the treated and the pandemic dummies (*Treated* x *Pandemic*), which captures the average effect of the COVID-19 pandemic. All regressions control for students' fixed effects and semester fixed effects. The specification in Column 1 also includees cohort-specific trends (see Section 4.2).

The results in column 1 of Panel A show that, on average, the COVID-19 pandemic increased the number of credits achieved in each semester by 1.4 points, which corresponds to a 7 percent increase in the average number of credits or to approximately 0.1 standard deviations.

The positive effect is confirmed when we focus on the UNDER/ADMIN sample in column 2. In this case, we find that the number of semester credits increased by almost 3 points (14% of the average value and 0.26 standard deviations). Reassuringly, Table A1 in the Appendix shows that when we apply to the ADMIN dataset the same selection rules used to construct the UNDER/ADMIN sample (i.e., using only the first three semesters of the two 2018 and 2019 cohorts and focusing on bachelor's students), we find a very similar impact size of approximately 2.4 credits, which means increasing the average number of credits by 13 percent (0.19 standard deviations). This suggests that the UNDER sample is representative of the overall student population.

Table 2. Impact of the COVID-19 pandemic on academic achievement

	(1) ADMIN	(2) UNDER/ADMIN
Panel A. Dep var: total credits		
Treated × pandemic	1.406***	2.977***
	(0.186)	(0.351)
Average outcome	19.51	21.39
Observations	139,924	17,202
Number of id	42,865	8,172
Panel B. Dep var: dummy=1 if inactive		
Treated × pandemic	-0.012**	-0.044***
	(0.005)	(0.007)
Average outcome	0.168	0.0621
Observations	139,924	17,202
Number of id	42,865	8,172
Panel C. Dep var: GPA		
Treated × pandemic	0.180***	0.100
	(0.037)	(0.078)
Average outcome	26.11	25.78
Observations	112,747	15,681
Number of id	35,891	7,608

Notes: All estimates include individual fixed effects and semester fixed effects. Estimates in column 1 include cohort-specific time trends as well. Estimates in column 1 are obtained on the ADMIN sample of master's and bachelor's students belonging to the 2016 to 2019 cohorts. Estimates in column 2 are obtained on the UNDER/ADMIN sample of bachelor's students belonging to the 2018 to 2019 cohorts. Total credits are the total number of credits earned in each semester. Inactivity is the probability of not gaining any credit in a given semester. GPA is the average of all the grades obtained in the exams in each semester weighted by the credits awarded in each exam. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

The results on inactivity in panel B are consistent with the results on the number of credits: the COVID-19 pandemic contributed to a slight reduction in inactivity rates of approximately one percentage point (see column 1), which increases to approximately four percentage points when estimates are replicated using the UNDER/ADMIN sample (column 2).

Finally, the results on GPA (panel C) indicate a small positive impact of approximately 0.2 points, which corresponds to approximately 0.7 percent of the average GPA in the whole sample of students. The coefficient decreases to approximately 0.1 in the UNDER/ADMIN sample (where it fails to reach statistical significance).

Overall, our results show a positive impact of the COVID-19 pandemic on the performance of UNIMIB students that, on average, increased the number of earned credits and the average GPA and reduced the probability of being inactive.

In the following sections, we first investigate possible mechanisms explaining this positive impact (Section 5.2); second, we test whether the positive effect is heterogeneous across students with different characteristics (Section 5.3).

5.2 Mechanisms

Many features of the pandemic potentially had a bearing on university students' performance, and it is hard to know which effect is being reflected in our estimates. However, thanks to the information contained in the UNDER survey data, we can investigate two channels potentially mediating the positive impact of COVID-19 on university students' academic achievement. The first channel is related to the increase in study time resulting from the restrictions during the lockdown that drastically reduced opportunities for social interactions and leisure time. The second channel is the availability of class recordings that allowed students to listen to lectures at the most convenient time and as many times as they wanted.

Such aspects could have partly counteracted the negative impact of the pandemic due to, among other factors, decreased interactions with peers and teachers, difficulties in adapting to the new teaching technology, direct health effects, and increased psychological strain.

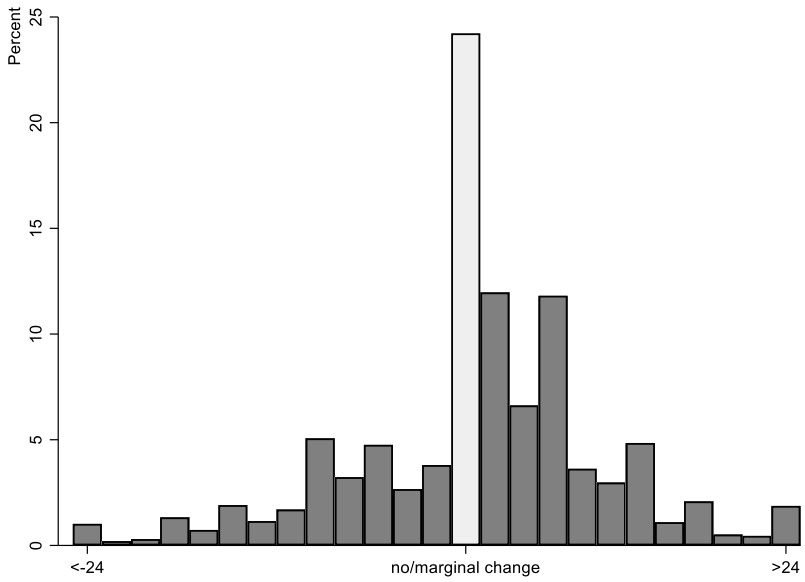
5.2.1 Study time

In Italy, on March 8th, 2020, a government decree drastically restricted the movement of people. The limitations were geographically differentiated according to the severity of the pandemic. Within Italy, the northern regions were hit more severely, and Lombardy, in particular, was the most affected region, accounting for 41 percent of all cases in Italy, 58 percent of deaths at the end of March 2020, and a quarter of all Italian cases and 39 percent of deaths in the second COVID-19 wave at the end of

November 2020.[10] As a consequence, in Lombardy, the implementation of confinement measures was particularly strict, with very strong restrictions on the movement of people, who could leave their homes only to obtain food and medicines or for exceptional work- and health-related reasons. All sports and leisure activities typically carried out by university students during their free time (cinemas, pubs, and clubs) were suspended, and students had no chances for performing such activities outside their own houses. This implied that the time students could allocate to study increased momentously, and substitution of leisure activities with studying may have taken place, resulting in improved academic performance.

We provide evidence on the study time mechanism exploiting the information contained in our survey. In particular, the survey asks a question on the number of hours studied in a typical week of the current semester (hit by the pandemic) and the counterfactual number of hours the students think they would have studied in the case of traditional in-presence teaching (i.e., as before the COVID pandemic). We compute the difference between the actual and counterfactual study hours, which we label *change in study time*. We show the distribution of this variable in Figure 2.

Figure 2. Variation in weekly study time (hours, post- and pre-COVID-19)



Note: This figure reports the distribution of the difference between the answers to the question: "*How many hours per week did you study on average during the current semester*?" and the answer to the question: "*How many hours per week do you think that you would have studied had teaching been in-person?*". With exception of the labelled bars, each bar represents a two-hour interval.

[10] Data from daily reports provided by the Ministry of Health and available at https://opendatadpc.maps.arcgis.com/apps/dashboards/b0c68bce2cce478eaac82fe38d4138b1 .

Approximately one-fifth of students did not substantially vary their study time (i.e. they either did not change it at all or changed it by less than two hours per week/20 minutes per day, light bar in Figure 2). The majority of them (54%) reported having increased their study time by more than 2 hours per week in comparison to how would have studied if classes had been in person; the remaining 24 percent reported a reduction in study time by more than 2 weekly hours. On average, students studied 2.93 hours more each week.

To test whether the increase in study time is a possible channel transmitting the positive impact of the COVID-19 pandemic on academic achievement, we augment the baseline model in equation (1) by interacting the treatment dummy with dummies taking the values of one for students that, with respect to what they think would have happened in the prepandemic period, *i*) reduced their study time by more than 2 hours per week; *ii*) either did not vary or varied marginally (i.e., by less than 2 hours per week) their study time; *iii*) increased their study time by more than 2 hours per week. We focus only on the fall semester of 2020 because the questions about study time refer to the second pandemic semester.

The results, reported in Figure 3, show that the effect of the pandemic is null for students who decreased their study time. All students who did not reduce their study time improved their performance, and the highest impact, equal to approximately three earned credits, is estimated for students who increased their study time by more than 2 hours per week,[11] providing empirical support to the fact that the increase in study time related to the strict confinement measures has contributed to channelling the positive effect of the COVID-19 pandemic on students' achievement.

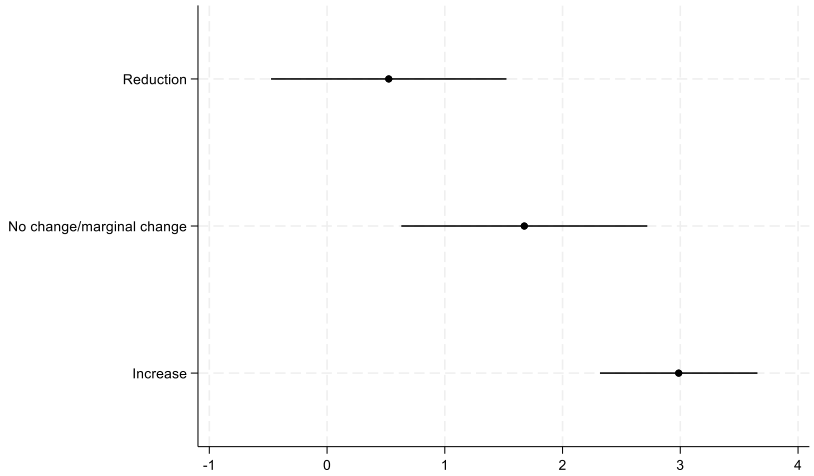
One concern with these results regards the potential endogeneity of the study time variable because there are potentially unobserved factors affecting study time and achievement simultaneously. However, we note that in our estimates we control for individual fixed effects that capture time-invariant students' characteristics, including variables such as personality traits or family background that likely affect the individuals' study time.

Another potential concern regards reverse causality if high-achieving students increase their study time because, for instance, they are more motivated. However, since the study time variables are elicited before the exam session, we can reasonably exclude that reverse causality is an issue.

Overall, this evidence confirms that very strict confinement measures resulted, on average, in more study time, which, in turn, was associated with improved academic performance during the pandemic period.

[11] The coefficient of the interaction treated x pandemic x increase is significantly higher compared to the coefficient of the interaction treated x pandemic x no change/marginal change (F-test equal to 4.30 and p-value equal to 0.0382).

Figure 3. Estimates' heterogeneity by variation in study time (pre- and post-COVID-19)



Notes: The figure reports the estimated coefficients and the 95 percent confidence intervals of the *Treated* × *Pandemic* dummy (see equation 1) on the number of semester credits by variation in the weekly study time (decrease in study time, no variation, less than 10 hours increase, and more than 10 hours increase). Estimates are obtained on the sample of bachelor's students belonging to the 2018 and 2019 cohorts and using the UNDER/ADMIN dataset. All estimates include individual fixed effects and semester fixed effects.

5.2.2 Class recording

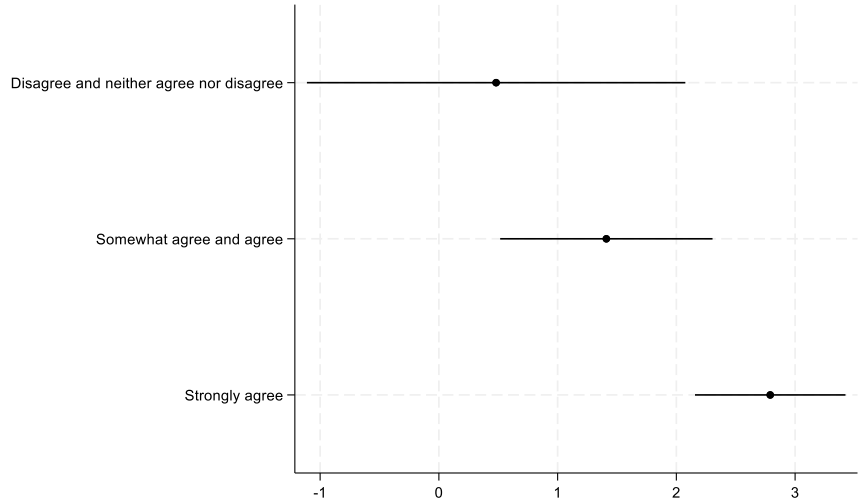
A second potential mediating factor of the positive effect of the COVID-19 pandemic on academic achievement is the organizational advantage provided by one aspect of online teaching. During the pandemic period, all UNIMIB professors were asked to record classes and make the recordings available on their courses' web pages for approximately six months. Therefore, students could listen to lectures at the most convenient time for them and as many times as they wanted.

To investigate this transmission channel, we exploit one survey question asking students whether the they agree with the following statement: *"With respect to traditional in-presence teaching, with remote teaching, your possibility of attending classes increased because you can listen to recorded lectures according to your time availability"*. Answers are on a seven-point scale, from "Strongly disagree" to "Strongly agree". The answer to this question captures the extent to which each student valued the opportunity provided by one specific aspect of remote teaching, namely, the availability of class recordings. As expected, the large majority of students agree with the statement (their answer is greater than 4), confirming that most of them had a perception of getting a personal benefit from the availability of online recordings.

To obtain supporting evidence on whether the increased flexibility of remote teaching related to class recordings has played a role in channelling the positive effect of the COVID-19 pandemic, we augment the baseline model in equation (1) and interact the treatment dummy with dummies taking the values of

one for students that *i*) either disagree or neither agree nor disagree with the statement (i.e., answers from 1 to 4); *ii*) agree (i.e., answers equal to either 5 or 6); *iii*) strongly agree (i.e., answers equal to 7).

Figure 4. Estimates' heterogeneity by opinion about the improved possibility of listening to classes during distance learning



Notes: The figure reports the estimated coefficients and the 95 percent confidence intervals of the *Treated* × *Pandemic* dummy (see equation 1) on the number of semester credits by agreement with the question: *"With respect to traditional in-person teaching, with remote teaching, the possibility of attending classes increases because you can listen to recorded lectures according to your time availability*" (disagree/neither agree nor disagree; somewhat agree/agree; strongly agree). Estimates are obtained on the sample of bachelor's students belonging to the 2018 and 2019 cohorts and using the UNDER/ADMIN dataset. All estimates include individual fixed effects and semester fixed effects.

The results, reported in Figure 4, show a null effect for students who did not perceive that class recording improved their possibility of listening to classes compared to traditional in-person teaching. In contrast, the effect is positive for students who perceived a benefit from class recordings, and it increases in the strength of this perception, suggesting that this channel contributed to mediate the positive impact of the COVID-19 pandemic.

Overall, the results in this section provide evidence in favour of two channels shaping the positive effect of the COVID-19 pandemic on students' careers. The first is related to the increase in study time due to the very strict lockdown measures in place in Italy, especially in the northern regions, so that most leisure activities were no longer available and time potentially available for studying increased; the second is related to the increased flexibility of listening to classes without a fixed time schedule thanks to the availability of online recordings.

5.2.3 Additional channels

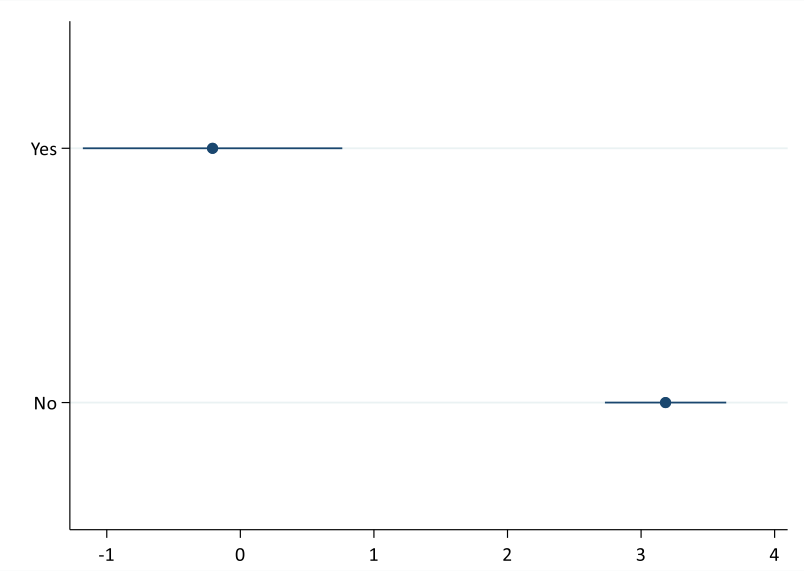
There are two additional potential factors that could have mediated the positive effect of the COVID-19 pandemic on students' achievement: cheating could have increased with online exams, and professors could have been more lenient in grading in response to the perceived difficulties of students. In this respect, the positive effect that we found would not be related to improved learning but to the violation of rules of conduct during assessment and/or to grade inflation. Even if we cannot directly test for the role of students' cheating and teachers' leniency, we discuss them in depth and suggest that these factors did not play an important role in explaining the positive effect of the COVID-19 pandemic that we found.

Regarding cheating, a very strict discipline was introduced at the UNIMIB regulating online assessments during the pandemic period. As mentioned in Section 2.1, the UNIMIB guidelines recommended administering exams orally, at least in part. According to data from a survey that we administered to UNIMIB teachers simultaneously with the student survey, we observe that among 1066 exams carried out during the first semester of the 2020-21 academic year, 43% were only oral, 20% were both written and oral and 37% were written with an additional optional oral examination. During the oral exams, students had to share their screen. For written exams, as mentioned in Section 2.1, two custom browsers were adopted to secure exam integrity, preventing many actions typically used for cheating, such as finding information about the exam content on the internet or on one's own PC or other devices and monitoring and recording very carefully the physical environment (both audio and video) where the student took the exam. Teachers were also asked to invite students to use the camera of their smartphone to capture the computer screen and the room, which is considered a good implementable solution for contrasting cheating (Bilen and Matros, 2021). Moreover, in case of suspected cheating, the instructor was required to review the recording and eventually ask the student to retake the exam orally. Overall, the stringent discipline regulating written and oral exams strongly reduces the possibility that cheating explains the positive effect of the COVID-19 pandemic on students' achievement.

For teachers' leniency, even if we cannot exclude that teachers have become more generous (in terms of pass rates and grades) in times of crisis, we use survey information to provide supporting evidence that students had better outcomes because they actually learned more. Specifically, we use a question that, for each attended course, asks students about the perception of their learning of the topic of the course during the remote teaching pandemic period (compared to what they think it would have been with traditional in-person teaching). Possible answers are "*Strongly penalized*", "*Partially penalized*", "*The same*", "*Partially improved*", and "*Strongly improved*". Very importantly, the question was asked before students took the exams and saw the marks. For each student, we construct a dummy for students with a perception of penalized learning in all courses attended, obtaining a measure of self-reported learning differential due to distance learning during the pandemic with respect to prepandemic in-person

teaching. We augment the baseline model in equation (1) by interacting the previous dummy with the treatment dummy.

Figure 5. Estimates' heterogeneity by opinion about the perception of penalized learning during distance learning



Notes: The figure reports the estimated coefficients and the 95 percent confidence intervals of the *Treated* × *Pandemic* dummy (see equation 1) on the number of semester credits interacted with a dummy variable taking the value of one for students who believe that their learning of the topic of all the courses during the remote teaching pandemic period had been penalized (compared to what they think it would have been with traditional in-person teaching). Estimates are obtained on the sample of bachelor's students belonging to the 2018 and 2019 cohorts and using the UNDER/ADMIN dataset. All estimates include individual fixed effects and semester fixed effects.

The results in Figure 5 show that students with a perception of penalized learning did not earn more additional credits during the pandemic, while for students who did not share the same perception, we find an increase of more than 3 credits, providing suggestive evidence that our measures of academic performance reflect actual learning and not (only) either cheating or instructors' leniency. Incidentally, our data also show that the perception of penalized learning is lower for students who increased more their study time during the pandemic and for those who perceived an improvement in the possibility of listening to classes during remote teaching, providing further support for the mechanisms that we have identified for the positive effect of the COVID-19 pandemic.

Overall, although we cannot exclude that cheating and leniency played a role during the pandemic period, the evidence presented in this section is consistent with study time and class recordings having been channels transmitting the positive effect on achievement of COVID-19 that emerges from our estimates. In the following section, we explore the potential heterogeneity of the COVID-19 effect.

5.3 Heterogeneity

The average positive impact of the COVID-19 pandemic presented in Table 2 could mask heterogeneous effects for different subgroups of students. To test for heterogeneity, we augment the baseline equation (1) by interacting the *Treated* x *Pandemic* and the semester dummies with dummy variables for different subgroups of students. In the analysis, we focus on the number of credits as the outcome variable, but we find similar results for the other two outcomes.[12] We estimate heterogeneous treatment effects by first using the sociodemographic information available in the administrative data and then by exploiting the rich information on individual characteristics that we collected with the UNDER survey.

We first test whether the impact of the COVID-19 pandemic differs depending on the severity of the pandemic to check whether direct health effects played a role. We use data on students' municipality of residence and compute the intensity of the pandemic by excess mortality at the municipality level, which is the percentage increase in the number of deaths observed in 2020 with respect to the previous four years in the municipality of residence (see Cerqua et al. 2021 for more details). We then create dummies for students living in municipalities above and below the median value of excess mortality. Higher mortality is likely to be associated with increased psychological and physical strain on students and with a difficult environment for the students and their families (Betthäuser et al. 2022), which would reduce the ability and motivation to focus on studying and preparing for exams. However, our results, reported in the bottom panel of Figure 6, show no statistically significant differences in the COVID-19 effect between students residing in high- and low-mortality municipalities.

We next turn to individual students' characteristics and test for the existence of heterogeneous effects by gender, end of high school's final grade, and family income.[13] For the last two variables, we separate students above and below the median value of the respective variable's distribution. The results are reported in Figure 6 and again suggest that the impact of the COVID-19 pandemic has been uniform along these students' characteristics.

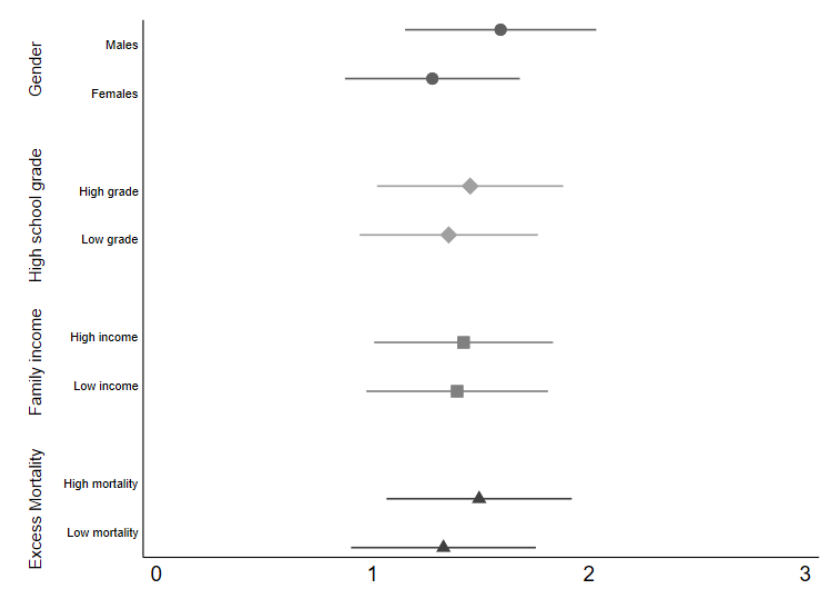
The richness of the UNDER survey allows us to further test for the existence of heterogeneous effects along other individual dimensions: the type of secondary school attended, parental education, and students' working status. Specifically, we split students according to whether they attended an academic or a technical/vocational high school, whether they are first-generation university graduates or not (i.e., whether they have at least one parent with a college education) and whether they were working students (both full time and part-time) before the pandemic.

[12] Results of the heterogeneity analysis for the probability of inactivity and for GPA are available upon request.

[13] The tuition fees for students vary according to the financial situation of the household, as confirmed by the ISEE (Equivalent Economic Status Indicator). Students have to present their ISEE each year before paying the fees, and we use this information to measure family income.

For working students, the organizational advantage of increased flexibility could have been particularly beneficial, and the availability of recorded classes made it easier to combine study and work.

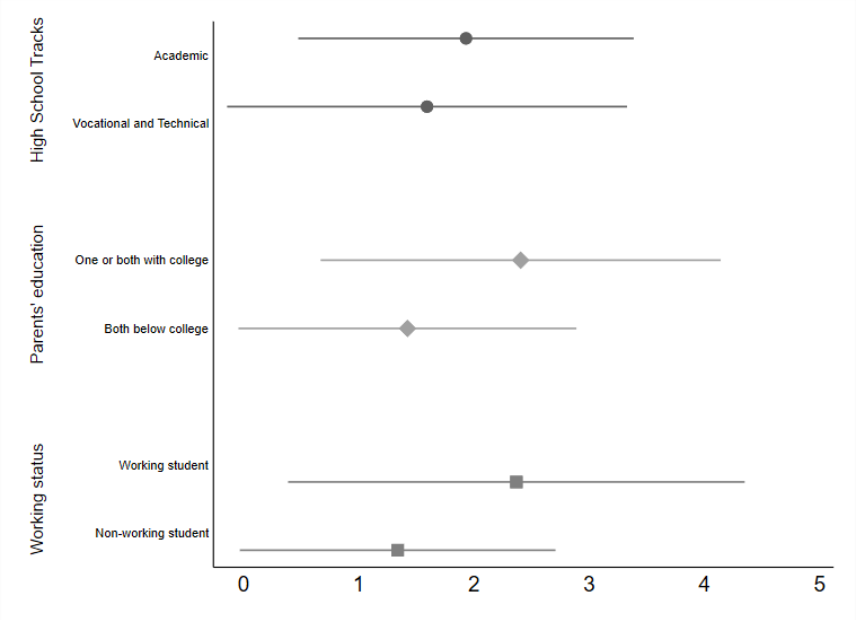
Figure 6. Heterogeneity by student characteristics and by excess mortality. ADMIN data



Notes: The figure reports the estimated coefficients and the 95 percent confidence intervals of the *Treated* × *Pandemic* dummy (see equation 1) on the number of semester credits by student characteristics and by excess mortality in the municipalities of residence from separate regressions. Estimates are obtained on the sample of master's and bachelor's students belonging to the 2016 to 2019 cohorts and using the ADMIN dataset. For high school final grade, family income and excess mortality, high and low values are the values above and below the median value, respectively. All estimates include individual fixed effects, semester fixed effects, and cohort-specific time trends. Excess mortality is the percentage increase in the number of deaths observed in 2020 with respect to the previous four years in the municipality of residence.

Figure 7 reports the results: while students coming from an academic high school, having a higher level of parental education and a working-student status gained, on average, more additional credits with respect to students with, respectively, a technical/vocational high school degree, a lower level of parental education and who were not working students, the groups' differences are never statistically significant. Overall, the heterogeneity analysis presented in this section shows that the improvement in academic performance is not driven by any specific subgroups of students and reveals that all students experienced an increase in academic achievement during the COVID-19 pandemic.

Figure 7. Heterogeneity by students' characteristics. UNDER/ADMIN data



Notes: The figure reports the estimated coefficients and the 95 percent confidence intervals of the *Treated* × *Pandemic* dummy (see equation 1) on the number of semester credits by student characteristics from separate regressions. Estimates are obtained on the sample of bachelor's students belonging to the 2018 and 2019 cohorts and using the UNDER/ADMIN dataset. All estimates include individual fixed effects and semester fixed effects.

6. Robustness

In this section, we perform several robustness tests of the model's results. First, we run a placebo regression; second, we test for the validity assumptions of the TWFE estimator; third, we assess the sensitivity of our results to changes in the model specification and in the choice of the sample. Throughout this section, we run robustness exercises using the administrative data and compare them to the baseline estimates, which, for convenience, we report in column 1 of Table 3.

6.1 Placebo test and validity assumptions of the TWFE estimator

Universities are institutions that evolve over time, change the content of the courses offered and have high faculty turnover. Thus, one may worry that our estimates are picking up some underlying trends of improvement in the number of credits obtained each semester by younger enrolment cohorts. To confirm that this is not the case, we run a placebo test and re-estimate equation (1) by switching back one year in the treatment period, i.e., as if the COVID pandemic happened during the 2018-19 academic year rather than in the 2019-20 academic year. As column 2 of Table 3 shows, we find a non-statistically significant treatment effect and thus conclude that our results are due exclusively to the COVID-19 pandemic.

We then pay closer attention to the TWFE model in equation (1). As suggested by the recent literature, estimates can be biased if the timing of the treatment is staggered and treatment effects are

heterogeneous (Sun and Abraham, 2021). The COVID-19 pandemic occurred in the same academic years for every cohort, but different cohorts were affected in different semesters of their university career, and the effects may be heterogeneous across cohorts. Furthermore, the TWFE model uses pretreatment observations of treated units as controls, which requires using a reweighting scheme, even if the inclusion of a never-treated cohort reduces the risk of having a biased coefficient.

Table 3. Robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline estimates§	Placebo test (pandemic in the AY 2018-19)	ATT Callaway and Sant'Anna procedure	Using only the 2016 cohort as control	With field-specific time trends	With course-specific time trends
Treated*pandemic	1.406***	-0.230	1.10***	1.533***	1.719***	1.708***
	(0.186)	(0.252)	(0.119)	(0.245)	(0.217)	(0.216)
Observations	139,924	97,709	17,202	105,124	139,924	139,924
Number of id	42,865	32,766	8,172	35,142	42,865	42,865
Field specific time trends	No	No	No	No	Yes	No
Course specific time trends	No	No	No	No	No	Yes

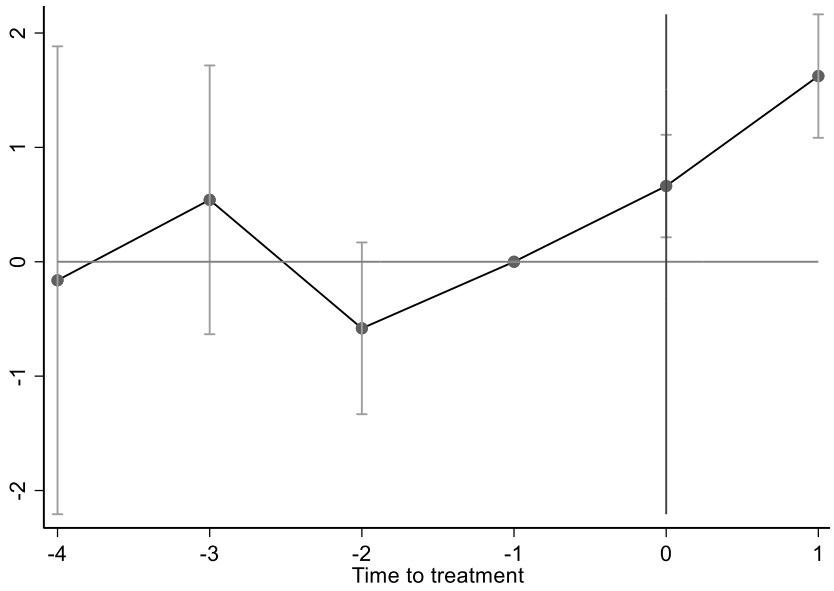
Notes: § from Table 2, column 1. Column 2 reports the estimates of a placebo test, run as if the pandemic waves occurred in 2019 rather than 2020. Column 3 reports the estimation of the Average Treatment on the Treated computed by using the Callaway and Sant'Anna (2021) procedure. In column 4, we exclude the cohort enrolled in 2017. Columns 5 and 6 also include field- and course-specific time trends, respectively. Each regression includes individual fixed effects, semester fixed effects, and, excluding column 3, cohort×semester fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

To check if our results are affected by these biases, we proceed as follows. First, we adopt the approach proposed by Sun and Abraham (2021) and use their interaction-weighted estimator for event studies, which solves the problem of heterogeneous effects in event studies. The results are reported in Figure 8. Even after applying Sun and Abraham's weights, our baseline results are confirmed: the effect of the COVID-19 pandemic is positive and significant in the first period, and it is slightly higher in the second wave. One explanation for the higher impact in the second wave is that while the first wave (March 2020) was sudden and unexpected, by the time the second COVID-19 wave hit Italy (October 2020), both students and teachers had more time to adapt to the new online teaching and learning approaches. We interpret this result as evidence of a learning process by teachers and students that in the second pandemic wave had accumulated more experience in dealing with online teaching and distance learning and were able to gain more credits than during the first pandemic wave. Furthermore, the event study confirms the absence of a pretreatment differential trend between different cohorts. We then propose a second test and follow Callaway and Sant'Anna (2021) by computing their reweighted estimator of the

average treatment effect on the treated (ATT). The results are reported in column 3 of Table 3 and they show that the estimated ATT is qualitatively similar to our baseline estimates.

As a last robustness check, we use as a control the 2016 cohort (the only cohort in our sample that has never been treated), and we find that the main results do not change (column 4, Table 3). Considered altogether, this first set of robustness checks shows that the empirical strategy is robust to the presence of heterogeneous and dynamic effects.

Figure 8. Event study applying the interaction-weighted estimator. Effect on the number of credits.



Notes: This figure uses Sun and Abraham's (2021) event study estimator to control for the potential heterogeneous effect of COVID-19.

6.2 Sensitivity analysis: using different subsamples and model specifications

We begin this second set of robustness exercises by augmenting the baseline specification in equation 1 with field- and course-specific time trends. The results are reported in columns 5 and 6 of Table 3. The time trends capture any specificity in the number of credits gained by students in each semester of their university career related to their field of study or to the specific course they were attending. As Table 3 shows, the results are largely unchanged.

To further explore the differential impact that a particular field of study may have on the number of credits and to check that no field of study acts as an outlier and drives the main results, Table A2 in the Appendix reproduces the baseline results by dropping each field of study in turn. We find that the results are qualitatively similar to the baseline estimates, and no strong effect emerges. However, there are some fields of study that have particularly relevant effects on the estimates. In particular, excluding either

economics and statistics or sciences decreases the magnitude of the baseline effect on the number of credits, suggesting that students in these fields have benefited slightly more from the COVID-19 pandemic.

7. Conclusion

The COVID-19 pandemic and its side effects significantly impacted the educational sector. At the university level, the difficulty in adapting to the new learning environment, together with isolation and psychological and physical health problems, challenged the learning process. At the same time, the sudden increase in the time potentially available for studying due to the exceptionally strict confinement measures adopted, and the recordings of classes often made available for students during the pandemic period, allowing them to listen to lectures asynchronously according to their own pace and with an unlimited possibility to revisit them, may have favoured students' achievement. Overall, the COVID-19 pandemic and its byproduct have affected academic achievement in many ways, but the direction of the overall effect is ambiguous.

In this paper, we focus on Lombardy, the most severely affected Italian region, and we examine the impact of the COVID-19 pandemic on university students' achievement one year after the pandemic. We use data collected with a unique survey instrument merged with administrative data covering the universe of four cohorts of students from a major Italian public university in Milan, and we apply a difference-in-difference fixed effect estimator.

We find a statistically significant positive impact of the COVID-19 pandemic on the number of credits and on GPA and a reduction in the probability of being inactive. The results are not driven by specific subgroups of the student population, and they do not differ according to the severity of the pandemic in the place of residence.

Exploiting the very rich information collected with the survey instrument, we provide for the first time evidence on two channels potentially mediating the positive effect of the COVID-19 pandemic. We observe that during the pandemic period most students studied for more hours in comparison to how would have studied if classes had been in person, and we find that the positive effect of the COVID-19 pandemic is increasing in the variation in study hours, confirming the increased availability of time as a transmission mechanism. To the best of our knowledge, this is the first paper documenting empirically the role of increased study time in academic achievement during the pandemic, which represented an exogenous shock affecting the time potentially available for studying. This finding contributes to the economic and psychological literature examining the association between study time and achievement and is consistent with the literature showing that study time is a crucial input of the education production function (Stinebrickner and Stinebrickner, 2004, 2008; Jürges and Khanan, 2021).

The second mechanism is related to class recordings. Using survey information on the perceived improvement in the possibility of listening to classes thanks to the availability of class recordings, we provide empirical evidence in favour of this channel.

The first implication of our results relates to the usefulness of class recordings for students' learning. Moreover, policies that free up time for studying like compact class schedule or more places in student housing that help reducing commuting time could be helpful.

Overall, even if our results show that during the pandemic period students were able to improve their academic achievement, other aspects need to be considered. For instance, evidence from our survey shows that an overwhelming majority of students report serious deterioration of interactions with their peers and with the teachers due to distance learning (specifically, more than 85 percent report worsened interactions with peers and more than 70 percent worsened interactions with teachers), which could negatively affect students' ability to interact with others. Future research will no doubt be useful in analysing other outcomes, for instance, related to noncognitive skills valuable in the labor market such as the ability to interact with others or work in groups.

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Appendix

Figure A1. Identification strategy. ADMIN sample (master's degree students)

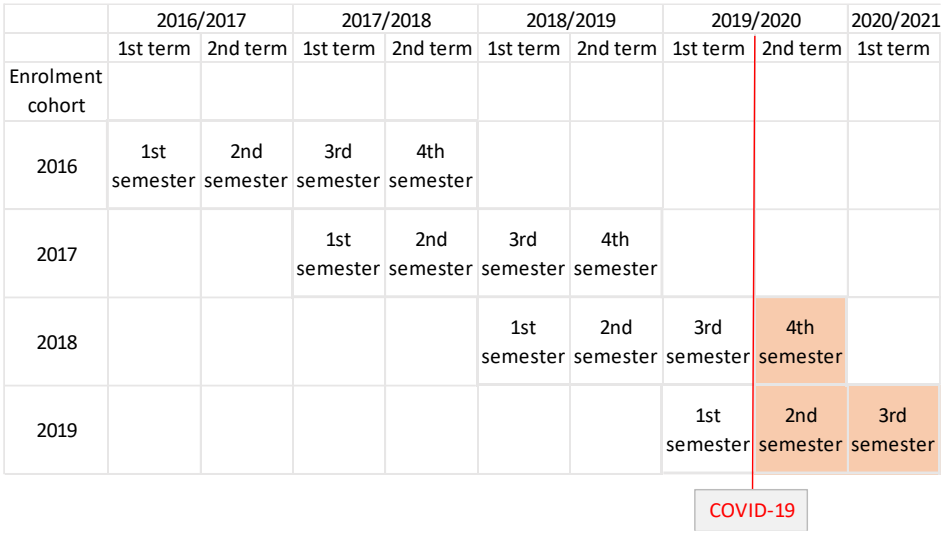

Table A1: Impact of COVID-19 on academic achievement. Restricted ADMIN sample

	Restricted ADMIN sample
Panel A. Dep var: total credits	
Treated × pandemic	2.383***
	(0.220)
Average outcome	17.98
Observations	39,236
Number of id	18,201
Panel B. Dep var: dummy=1 if inactive	
Treated × pandemic	-0.040***
	(0.006)
Average outcome	0.173
Observations	39,236
Number of id	18,201
Panel C. Dep var: GPA	
Treated × pandemic	0.118**
	(0.056)
Average outcome	25.49
Observations	31,150
Number of id	15,022

Note: All estimates include individual fixed effects and semester fixed effects. Estimates are obtained on the sample of all bachelor's students belonging to the 2018 to 2019 cohorts using the ADMIN dataset. Total credits are the total number of credits earned in each semester. Inactivity is the probability of not gaining any credit in a given semester. GPA is the average of all the grades obtained in the exams in each semester weighted by the credits awarded in each exam. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.

Table A2. Further robustness checks. COVID-19 effect on total credits

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Excluding						
	Economics and statistics	Educational sciences	Law	Medicine and Surgery	Psychology	Sciences	Sociology
Treated*pandemic	0.858***	1.195***	1.597***	1.788***	1.706***	0.635***	1.822***
	(0.213)	(0.205)	(0.191)	(0.187)	(0.200)	(0.216)	(0.197)
Observations	104,983	117,518	134,081	132,261	123,542	104,603	122,556
Number of id	32,435	36,153	40,866	40,663	37,836	31,422	37,815

Note: All estimates include individual fixed effects, semester fixed effects, and cohort-specific time trends. Estimates are obtained on the sample of master's and bachelor's students belonging to the 2016 to 2019 cohorts using the ADMIN dataset. Total credits are the total number of credits earned in each semester. Estimates in each column are obtained excluding students of the area indicated in the respective column. *** denotes significance at the 1% level; ** denotes significance at the 5% level; * denotes significance at the 10% level.