Persistent and Gender-Unequal Impacts of the COVID-19 Pandemic on Student Outcomes in Italy

Léonard Moulin et Mara Soncin

DOCUMENTS DE TRAVAIL 277

Persistent and Gender-Unequal Impacts of the COVID-19 Pandemic on Student Outcomes in Italy

Léonard Moulin, Mara Soncin

Octobre 2023

Persistent and Gender-Unequal Impacts of the COVID-19 Pandemic on Student Outcomes in Italy

Léonard Moulin[*], Mara Soncin[†]

October 27, 2023

Abstract

The learning loss caused by the COVID-19 pandemic on students' outcomes is likely to have lasting effects on which evidence is lacking. Using a difference-in-differences design through a triple difference estimator, we identify the evolution of the COVID-19 pandemic's impact on Italian students' test scores in the two years following the COVID-19 outbreak. Our findings indicate a persistently negative effect on mathematics and reading scores for grade 5 and grade 8 students in 2021–22, two years after the pandemic began, despite a statistically significant recovery compared to the previous school year. Our analysis highlights the pandemic's disproportionate impact on girls, leading to a decrease in their academic performance and an intensification of gender-based inequalities (with the exception of grade 8 reading). Our results also show that the pandemic had a greater adverse impact on the academic achievement of students who experienced more prolonged classroom closures.

JEL codes: H75, I21, I24, I28.

Keywords: COVID-19, learning loss, school closure, gender.

[*]Institut national d'études démographiques (INED), F-93300 Aubervilliers, France. E-mail: leonard.moulin@ined.fr.

[†]School of Management, Politecnico di Milano, Milan 20156, Italy. E-mail: mara.soncin@polimi.it.

1 Introduction

The COVID-19 pandemic, as well as the measures taken to contain the spread of this infectious disease, led to unprecedented changes in our contemporary societies. Beyond its effects on health, with nearly 7 million deaths to date, the COVID-19 pandemic and the resulting successive lockdowns have had major consequences in various domains, from the labor market to the environment, gender inequalities, etc. (Brodeur et al., 2021). In educational terms, the COVID-19 pandemic has created the greatest disruption of educational systems in human history, impacting more than 94% of the world's student population (Pokhrel and Chhetri, 2021). Recent research has increasingly confirmed the expected deleterious effects of COVID-19 on learning outcomes (see Betthäuser et al., 2023, for an extensive review of the literature).

Following the emergence of COVID-19 in China's Wuhan region in December 2019, Italy was the first country affected by the COVID-19 pandemic. As a consequence, it became the first country in the world to establish a national lockdown. Italian schools were closed beginning in late February 2020 until the end of the school year (June 2020). The COVID-19 emergency forced teachers and students to switch to a remote-only mode for several months to guarantee learning continuity. A particularly prolific literature has highlighted the unprecedented negative effects of this lockdown on the learning of students in Italian schools. One of the first studies to examine the effects of the COVID-19 pandemic on students' learning loss is that of Contini et al. (2022), which investigates educational achievement in grade 3. Using longitudinal data collected in the province of Turin along with administrative data, they found that the pandemic decreased student performance in mathematics in primary education by 0.19 standard deviation (s.d.). They showed that this effect was greater for girls, for high-achieving students from low-educated families, and in schools with a disadvantaged social composition. Understanding the specific effects at the school level is one of the challenges taken on by the study of Bertoletti et al. (2023). Combining a survey of teaching practices during the crisis along with administrative data, Bertoletti et al. (2023) first highlight a learning loss in grade 5 ranging from 0.05 s.d. in mathematics to 0.28 s.d. in English reading, and in grade 8 from 0.03 s.d. in English reading to 0.16 s.d. in mathematics. Second, they explain the observed differences between schools in terms of teachers' ability to use digital tools and the leadership of school principals. The effects of the COVID-19 pandemic on students in Italy are also corroborated by the work of Borgonovi and Ferrara (2023) and Carlana et al. (2023), who found effects ranging from 0.08 to 0.17 s.d. and 0.05 to 0.14 s.d. respectively. In complement to these results on primary and lower secondary students, Battisti and Maggio (2023); Bazoli et al. (2022); Contini et al.

(2023) also report significant negative effects of the COVID-19 pandemic on upper secondary students in Italy.

All existing studies primarily focus on the immediate effects of COVID-19, specifically the school year following the pandemic (2020–21). In this paper we are interested not only in the immediate effect of the COVID-19 pandemic, but also in its persistent impact. Using data that enables us to track student progress on standardized tests, we explore whether the pandemic's effects persist over time by examining the impact of COVID-19 in both the 2020–21 and 2021–22 school years. Through a difference-in-differences design that compares the progress of exposed and non-exposed cohorts between grades 2 and 5 and between grades 5 and 8, we estimate the causal impact of the pandemic on the entire population of Italian students. We employ a triple difference estimator to examine the evolution of the COVID-19's impact on student standardized test scores in the two school years following the start of the pandemic. Our findings indicate a persistently negative effect of COVID-19 on mathematics and reading scores for grade 5 and grade 8 students in 2021–22 by 0.011-0.026 s.d., despite a statistically significant recovery in 2022 compared to the previous year. In particular, our analysis reveals that girls were disproportionately affected by the pandemic, experiencing a deterioration in academic performance and a worsening of gender inequalities (with the exception of reading in grade 8). Finally, we show that Italian regions imposing a greater number of days of school closure led to an even more negative of the COVID-pandemic on students' results.

This study contributes to the literature in two ways. First, we provide an analysis of the persistent effect of COVID-19 in terms of learning loss. The current literature provides contrasting evidence on the existence of a learning recovery after the first months of school closure. Using four waves of surveys of students aged 2-7 years in India, Singh et al. (2022) find that while the effect of COVID-19 persists over time, a recovery effect of the order of 0.11 to 0.28 s.d. can nevertheless be observed six months after the reopening of schools. In the US, using data from students in grades 3 through 8, Kuhfeld et al. (2022) also report a recovery effect. However, despite improvements in math and reading over the course of the 2020–21 academic year, students remained below the usual (pre-pandemic) benchmarks in the spring of 2021, with a deviation of 0.16 to 0.26 s.d. in math and 0.06 to 0.11 s.d. in reading. The authors find that this impact was even more pronounced among students with lower academic performance. An increasing learning deficit is instead reported by Gambi and De Witte (2023) for the Flemish region in Belgium. Analyzing 6-graders, the authors report -0.67 s.d. in Dutch language in 2022 compared to 2019, while the negative effect was smaller and equal to 0.40 s.d. the year before. Despite smaller in

magnitude, the increasing learning loss is reported across all the subjects.

Part of the literature also addressed the long-term effects of the pandemic. For example, Hanushek and Woessmann (2020) estimate that students who have experienced school closures during the COVID-19 pandemic will have a 3% lower lifetime income, and that the lower long-term growth related to these losses will result in an average decline for nations of about 1.5 percent in annual GDP for the remainder of the century. By providing information on the persistent effect of the pandemic, we are contributing to the emerging literature on the medium-term effects of COVID-19, and the question of recovery from learning loss in particular. Second, our study contributes to the literature on the gendered effects of the pandemic, adding to the existing literature on gender inequalities in the effects of the COVID-19 pandemic on student test scores. While Borgonovi and Ferrara (2023) highlight a gender-related effect in favour of boys, we go further by showing that this negative effect on girls persists over time, and indeed worsens between 2021 and 2022. This raises relevant questions in public policy terms on how to support girls during and beyond shocks of this magnitude. This result is even more remarkable in light of the literature on amplified impacts of the COVID-19 pandemic on women's employment (Meekes et al., 2023; Villarreal and Yu, 2022), which were particularly notable due to challenges with accessing dependable childcare and in-person schooling (Albanesi and Kim, 2021; Alon et al., 2020; Amuedo-Dorantes et al., 2023; Couch et al., 2022; Fuchs-Schündeln et al., 2020).

2 Background and data

The education system in Italy is structured into four stages: early childhood education and childcare, which is non-mandatory and is offered to children aged 0-5 years, the first cycle of education, which includes primary and lower secondary education and targets students aged 6-13 years, the second cycle of education, which is made of the upper secondary education characterized by a tracking system, and higher education. Compulsory schooling spans a duration of ten years, from the age of 6 to 16. Primary education starts at the age of 6 and continues for five years, covering grades 1 to 5. Lower secondary education begins at age 11 (grade 6) and continues for three years, concluding with grade 8. At the end of lower secondary education, students must pass an exam to be admitted to the subsequent phase of education. Upper secondary education starts at age 14 (grade 9) and spans five years to age 19 (grade 13). In upper secondary school, students can choose between different tracks (vocational, technical, or academic).

To assess the effect of the COVID-19 pandemic on students' test scores, we use data from national standardized tests administered by INVALSI (the Italian National Institute for the Evaluation of the Educational System). These tests are administered at the end of grades 2, 5, 8, 10, and 13 in mathematics and Italian.[1] They are administered to all students of each cohort, with the exception of the 2019-20 school year, due to the COVID-19 pandemic.[2] Given the full data availability and the absence of a tracking system, we measure the pandemic's effect on the results of pupils in primary and lower secondary school, using data from 2014-15 to 2021-22 school years for the entire population of Italian students. Given the possibility to follow students' performance over time, we focus on the last year of primary and lower secondary education (i.e., grades 5 and 8 respectively), tracking student performance in the previous test (i.e., in grade 2 and 5, respectively). In addition to test scores, the administrative dataset contains several information at individual level that reports student socio-demographic characteristics.

Summary statistics are shown in Table 1. As we are interested in the progression of students between grades 2 and 5 and grades 5 and 8, the descriptive statistics cover control and treatment groups at these grade levels. We observe that the characteristics of the pre-COVID-19 cohort and the post-COVID-19 students are very similar at all grade levels. The sample size is between 865,821 and 947,169 students depending on grade and cohort.[3] The sample is gender balanced. The proportion of students born in Italy from Italian-born parents is similar between cohorts and grades at around 90%. The level of education of the largest proportion of parents (both mothers and fathers, at 52% and 49% respectively) is an upper secondary diploma. The proportion of parents with tertiary education is lower, and higher for women than for men (22% for mothers and 16% for fathers). The majority of mothers are either in occupations in the "teacher, white-collar worker, military leader" category (36% on average across cohorts) or are stay-at-home mothers (30% on average across cohorts). The majority of fathers are in the "blue-collar worker or employed in the service industry" category (41% on average across cohorts). Less than 2% of the sample was in a grade level lower than the one normally associated with their age. The dataset also contains information regarding students' results on standardized national assessments. INVALSI uses standardized scores, which are normalized on a nationwide basis, with the average score set at 200 and the standard deviation at 40.

[1] There are also tests of English reading and listening, except fro grade 2.

[2] The test has been not administered also in 2020-21 school year for grade 10.

[3] We exclude from our sample students for whom we do not have a score in at least one of the grades, i.e. those whose performance cannot be calculated. Moreover, we only consider students who have enrolled in grade 5 (or grade 8) three years after having enrolled in grade 2 (or grade 5).

On average, student progression in the post-COVID-19 cohort is lower on average than in the pre-COVID-19 cohort.

3 Estimation strategy

We estimate the effect of the COVID-19 school closure on student achievement by comparing the progression in test scores between grades 2 and 5 and between grades 5 and 8 of the cohorts of students who were either exposed to the pandemic or not. Our two COVID-exposed cohorts of students were enrolled in grade 5 or 8 in 2020–21 or 2021–22. Our control group, the two cohorts of students not exposed to the pandemic, were enrolled in grade 5 or 8 in 2017–18 or 2018–19. Our strategy is summarized in Table 2. To estimate the effect of the pandemic on student learning, we use the following specification:

$$\Delta y_{i,r}^{g} = \alpha + \mathbf{X}_i'\beta + \delta T_i + \Theta_r + \epsilon_i \tag{1}$$

where $\mathbf{X}_i$ is a set of socio-demographic covariates for each student i, T_i is a treatment indicator, Θ_r is a region fixed effect, and ϵi is the error term clustered at the classroom level. We estimate this equation for each group g ($g = 2021$ and $g = 2022$), and separately by grade (5 and 8) and subject (reading and mathematics). In the context addressed here, verifying the parallel trends assumption is essential to establishing causal effects. Appendix Figure A1 provides evidence that parallel trends hold in our setting.

Our analysis investigates whether the effect of the pandemic on the cohort of students who were enrolled in grade 5 or 8 in 2020–21 was stronger or weaker than its effect on those enrolled in the same grades in 2021–22. In other words, we want to know whether the effect of the pandemic intensified or diminished over time. Formally, we need to estimate the difference between the two cohorts g: $\Delta y_{i,r}^{2022} - \Delta y_{i,r}^{2021}$.

This difference can be estimated using a triple-difference model (see Olden and Møen, 2022) of the form:

$$DDD_{i,r} = \alpha + \mathbf{X}_i'\beta + \mathbf{X}_i'\gamma G_i + \delta T_i + \lambda T_i G_i + \Theta_r G_i + \epsilon_i \tag{2}$$

where, in addition to the elements defined as above for Equation 1, G_i is a binary indicator of the cohort to which student i belongs. We estimate equation 2 separately by grade and subject.

In addition the baseline models, we also investigate the variability of results by gender and depending on the number of days schools were closed. Indeed, while all

the schools in Italy were closed from the start of the pandemic to the end of the 2019-20 school year, the days of school closure varied from region to region in the 2020-21 school year, depending on the severity of the COVID-19 spread and with a median of 87 days of school closure (see Table A3). In order to estimate a causal impact of the number of school closure days, we again use a triple-difference model to compare the test scores of students who experienced a number of school closure days either above or below the median. The three differences are (i) before and after, (ii) treatment and control group, and (iii) number of days of school closure falling above versus below the median. The equation to be estimated is of the form:

$$\Delta y_{i,r} = \alpha + \mathbf{X_i}'\beta + \mathbf{X_i}'\gamma C_i + \delta T_i + \lambda T_i C_i + \Theta_r C_i + \epsilon_i \tag{3}$$

with C_i is a binary variable that indicates whether the number of days of school closure that the student experienced in the focal year was either below or above the median.

4 Results

4.1 Main estimates

By estimating the model outlined in Equation 1, we assess the impact of the COVID-19 school closure on individual student achievement. Table 3 presents the average learning loss for the two pandemic school years – i.e. the cohorts tested one and two years after the beginning of the pandemic – and the evolution of that effect between the two cohorts. The results show an average negative effect of the pandemic of 0.01 s.d. in grade 5 and 0.03 s.d. in grade 8 for mathematics, and 0.02 s.d. in grade 5 and 0.03 s.d. for reading. These average effects conceal major disparities between cohorts. The impacts on the cohort who took their tests one year after the beginning of the pandemic (in 2021) were for the most part more negative than the impacts on those who took their tests a year later (in 2022). In particular, this is true for reading in both grades 5 and 8, and for mathematics in grade 8. One year after the pandemic, we estimate a learning loss in reading of 0.03 s.d. in grade 5 and 0.06 s.d. in grade 8, and of 0.03 s.d. in mathematics in grade 8.[4] The estimated effects for the year 2020-21 (the first school year following the COVID-19 outbreak) are slightly smaller than those presented in most previous studies on Italy. In grade 5, previously estimated negative effects range from 0.02 s.d. (Bazoli et al., 2022) to 0.13 s.d. in mathematics

[4]The lack of an effect of the COVID-19 pandemic on mathematics scores in grade 5 can be explained by the wide disparity in effects between regions (see Appendix Figure A2).

(Borgonovi and Ferrara, 2023). Some studies have even reported positive effects on reading (Bazoli et al., 2022; Borgonovi and Ferrara, 2023). For grade 8, previously estimated negative effects of the COVID-19 pandemic range from 0.05 in reading (Carlana et al., 2023) to 0.16 in mathematics (Bertoletti et al., 2023).[5] Our results replicate a common feature of previous studies in Italy, namely a greater learning loss in lower secondary than in primary education. At the international level, our effects are in line with those in the literature. In their meta-analysis of 42 studies across 15 countries, Betthäuser et al. (2023) find a substantial overall learning deficit of 0.14 s.d.

The estimated effects for the cohort 2021-22 (students who were in grade 2 or 5 in 2018–19, and in grade 5 or 8 in 2021–22) are generally negative but smaller than those from one year earlier. The exception is in grade 5 mathematics scores, for which we find no effect in 2021 and a negative effect of 0.02 s.d. in 2022. To determine whether these differences between cohorts are significant, we estimate the triple difference model in Equation 2. Mathematically, the estimated effect corresponds to the difference between the estimated effects for each cohort. With the exception of mathematics in grade 5, the results confirm a recovery effect in both subjects and grades between the two years. These results seem to indicate that despite the learning loss is still significantly affecting students' results, the effect of COVID-19 decreased with time.

We verify the robustness of these results in two ways. The first is to consider the students' economic, social and cultural status (ESCS)[6] instead of the parents' occupation and level of education. The results, presented in Appendix Table A1, do not differ from those presented above. The second is to swap the control cohorts between groups 2021 and 2022 (i.e. students in 2017–18 and 2018–19; see Table 2). The results, presented in Appendix Table A2, again remain unaffected.

4.2 Heterogeneity – gender

To explore the heterogeneity of the effect of COVID-19, we (i) estimate Equations 1 and 2 separately for girls and boys and (ii) determine whether the differences between girls and boys are significant by adding an interaction term for gender to Equations 1 and 2. Mathematically, the difference between the estimated coefficients for girls and boys obtained from Equation 1 estimated separately for each gender corresponds to the coefficient of the model in Equation 1 with the interaction variable. The

[5] Aggregating data from students in grades 5, 8, and 13, Battisti and Maggio (2023) found an overall learning loss of 0.15 s.d. in mathematics and 0.10 s.d. in reading.

[6] This variable is only available for students enrolled in grades 5 and 8.

results, presented in Table 4, show that the effects of the COVID-19 pandemic differ by gender. First of all, on average, the pandemic seems to have affected girls more than boys in all subjects/grade combinations other than mathematics in grade 8. In contrast to boys, the average effect of the pandemic for girls is negative in 2021 and 2022 in both grades and both subjects. Second, in 2021 girls were more affected by the COVID-19 pandemic in reading than in mathematics. The results amount to catch-up effects: while girls generally perform better than boys in reading and less well in mathematics (Contini et al., 2017; Guiso et al., 2008), in the first year after the COVID-19 outbreak, girls' reading scores were more affected than those of boys, while the opposite happened to mathematics. In detail, the effect of the pandemic on test score progress is a difference between girls and boys by 0.07 s.d. in grade 5 and 0.10 s.d. in grade 8 to the detriment of girls in reading, while in mathematics it is 0.07 s.d. in both grades 5 and 8, in favor of girls.

In 2022, the COVID-19 pandemic had a worse effect on girls than boys. Girls' disadvantage in test score progress compared to boys is very large, particularly in grade 5, at 0.14 s.d. in mathematics and 0.15 s.d. in reading (versus 0.03 s.d. in mathematics and 0.05 s.d. in reading in grade 8). The catch-up effect in favor of girls observed in 2021 in mathematics no longer applies: instead there is a gender penalty for girls in both subjects and grades. Next, by estimating the triple difference model in Equation 2, we can analyze the changes in educational inequalities between girls and boys across the two COVID-19 pandemic cohorts (i.e., 2021 and 2022). The results show that, unlike boys, girls' learning loss increased between the first and second cohorts, in all subject/grade combinations except reading in grade 8. In grade 5, girls' disadvantage with respect to boys was 0.03 s.d. in reading and 0.14 s.d. in mathematics, while in grade 8 it was 0.04 s.d. in mathematics. In the end, the difference between 2021 and 2022 across gender in mathematics is 0.21 s.d. in grade 5 and 0.10 s.d. in grade 8, while in reading is 0.09 s.d. in grade 5 to the detriment of girls. This reveals that the recovery effect observed as baseline result (see Table 3) is in fact mainly for boys (with the exception of grade 5 mathematics). Girls only experienced a recovery effect in grade 8 for reading.

4.3 School closure

This section presents the effect of the number of school closure days on student learning loss by means of a triple difference model. By estimating Equation 3, we obtain the effect of the duration of school closures on student achievement. We begin by choosing a threshold, i.e., the median number of school closure days (87) experienced by students in 2019-20 and 2020-21 school years by region (see Table

A3). We then divide the students into two groups, those who experienced fewer days of school closure than the median, and those who experienced more, and we estimate the difference between the two groups in the effects of the pandemic. The results are presented in Table 5. The learning loss of students who faced an above-average number of school closure days in the 2019–20 and 2020–21 school years was greater than that of students who faced fewer school closure days by 0.08 s.d. in grade 5 and 0.02 s.d. in grade 8 for mathematics, and 0.06 s.d. in grade 5 for reading. In Appendix Table A4 we assess the robustness of our estimate by increasing the threshold (setting it at 99 days). The students in the group with a particularly high number of school closure days (99 or more) experienced even greater learning loss, up to 0.24 s.d. in mathematics and 0.22 s.d. in reading in grade 5 with respect to the group that experienced a number below this higher threshold. This negative impact of additional school day closures is corroborated by the literature on the Italian context. Estimating the impact of additional school closure days at the municipal level using fixed effects regression, Battisti and Maggio (2023) find an additional learning loss of 0.04 s.d. in mathematics for students in grades 5, 8, and 13 in Sicily region. Using a difference-in-differences model in which the number of school closure days is a continuous variable interacting with a dummy variable representing at least one parent's occupation being eligible for remote work, Aparicio Fenoll (2022) shows that 100 days of school closures with online learning in the first pandemic school year magnified the disparity in language test results between children whose parents can work remotely and those whose parents cannot by 0.04 s.d. on language test scores and by 0.01 s.d. on math test scores.

5 Conclusion

The current research provides evidence on the magnitude and persistence of the negative effects generated by the COVID-19 school closure on student achievement in Italy. While previous research primarily examines the immediate impacts of COVID-19 during the academic year following the pandemic, our study expands the temporal focus. Using a difference-in-differences design, we estimate the effect of the COVID-19 pandemic on students' test scores in Italy both in the school year following the COVID-19 pandemic (2020–21) and in the following year (2021–22). Employing a triple difference model, we check whether the effect of the pandemic has diminished or increased over time. Our results demonstrate a significant and persistent adverse impact of the COVID-19 pandemic on mathematics and reading scores of both students in grades 5 and 8 during the 2021–22 school year. Importantly, however, the

results also highlight a statistically significant recovery compared to the preceding year. The findings point to a persistent learning loss, whose magnitude is, however, decreasing over time. Signals of recovery are in line with previous evidence in international contexts (Singh et al., 2022). It is worth to notice that, while the pandemic situation prevented the systemic opening of school in the summer 2020, the government supported the organization of summer programs in 2021 (in the period June-September), and this policy decision may affect the results observed in 2022. In this respect, policy aimed at supporting the recovery have proved to be effective (Gambi and De Witte, 2023).

However, the recovery has not been homogeneous. Our analysis underscores that girls have been disproportionately affected by the pandemic, with a decline in their academic performance and an exacerbation of gender disparities (except in grade 8 reading). The gender penalty observed in this article is even more alarming if combined with the findings of existing research on the labor market, which has demonstrated a "motherhood penalty" associated with COVID-19 (Couch et al., 2022). These results should alert public authorities to the need to design public policies that are more sensitive to gender inequalities in education and labour market.

Additionally, we find that the pandemic had an even more pronounced negative effect on the academic outcomes of students who endured longer school closures. This finding suggests a possible path to prioritize interventions of recovery.

A possible extension of this paper would follow these students for several years in order to analyze the long-term effects of the pandemic on their test scores in subsequent grades, as well as on their choice of pathways in upper secondary and higher education and their probability of dropping out. It is important to check that girls do not continue to pay a disproportionate price for the crisis in the long term.

Acknowledgements

We are grateful to INVALSI for giving us access to the administrative data used in this article. This paper benefited from discussions and helpful comments from Marta Cannistrà, Etienne Dagorn, Xavier D'Haultfoeuille, Per Engzell and participants at 1st workshop on AQMAPPS (Milan). Financial support for this study was received from the Ile-de-France Region, which funds the research chair of the first author (EX061002 - 21010352) . We are also grateful to Christopher Leichtnam and Paul Reeve for their help in editing the manuscript for grammar and syntax.

Declarations of interest

Declarations of interest: none.

References

Albanesi, S. and Kim, J. (2021), 'Effects of the COVID-19 Recession on the US Labor Market: Occupation, Family, and Gender', *Journal of Economic Perspectives* **35**(3), 3–24.

Alon, T., Doepke, M., Olmstead-Rumsey, J. and Tertilt, M. (2020), 'The Impact of COVID-19 on Gender Equality', *NBER working paper* **26947**.

Amuedo-Dorantes, C., Marcén, M., Morales, M. and Sevilla, A. (2023), 'Schooling and Parental Labor Supply: Evidence from COVID-19 School Closures in the United States', *ILR Review* **76**(1), 56–85.

Aparicio Fenoll, A. (2022), 'The Uneven Effect of COVID School Closures: Parents in Teleworkable vs. Non-Teleworkable Occupations', *IZA DP* (15754).

Battisti, M. and Maggio, G. (2023), 'Will the last be the first? School closures and educational outcomes', *European Economic Review* **154**(104405).

Bazoli, N., Marzadro, S., Schizzerotto, A. and Vergolini, L. (2022), 'Learning Loss and Students' Social Origins During the Covid-19 Pandemic in Italy', *FBK-IRVAPP Working Paper* (03).

Bertoletti, A., Cannistrà, M., Soncin, M. and Agasisti, T. (2023), 'The heterogeneity of Covid-19 learning loss across Italian primary and middle schools', *Economics of Education Review* **95**, 102435.

Betthäuser, B. A., Bach-Mortensen, A. M. and Engzell, P. (2023), 'A systematic review and meta-analysis of the evidence on learning during the COVID-19 pandemic', *Nature Human Behaviour* **7**(3), 375–385.

Borgonovi, F. and Ferrara, A. (2023), 'COVID-19 and inequalities in educational achievement in Italy', *Research in Social Stratification and Mobility* **83**, 100760.

Brodeur, A., Gray, D., Islam, A. and Bhuiyan, S. (2021), 'A literature review of the economics of COVID-19', *Journal of Economic Surveys* **35**(4), 1007–1044.

Carlana, M., La Ferrara, E. and Lopez, C. (2023), 'Exacerbated Inequalities: The Learning Loss from COVID-19 in Italy', *AEA Papers and Proceedings* **113**, 489–493.

Contini, D., Di Tommaso, M. L., Muratori, C., Piazzalunga, D. and Schiavon, L. (2022), 'Who Lost the Most? Mathematics Achievement during the COVID-19 Pandemic', *The B.E. Journal of Economic Analysis & Policy* **22**(2), 399–408.

Contini, D., Di Tommaso, M. L., Piazzalunga, D., Muratori, C. and Schiavon, L. (2023), 'A Lost Generation? Impact of COVID-19 on High School Students' Achievements', *IZA DP* (16008).

Contini, D., Tommaso, M. L. D. and Mendolia, S. (2017), 'The gender gap in mathematics achievement: Evidence from Italian data', *Economics of Education Review* **58**, 32–42.

Couch, K. A., Fairlie, R. W. and Xu, H. (2022), 'The evolving impacts of the COVID-19 pandemic on gender inequality in the US labor market: The COVID motherhood penalty', *Economic Inquiry* **60**(2), 485–507.

Fuchs-Schündeln, N., Kuhn, M. and Tertilt, M. (2020), 'The Short-Run Macro Implications of School and Child-Care Closures', *IZA Discussion Paper* **13353**.

Gambi, L. and De Witte, K. (2023), *The Uphill Battle: the Amplifying Effects of Negative Trends in Test Scores, COVID19 School Closures and Teacher Shortages*, KU Leuven, Department of Economics.

Guiso, L., Monte, F., Sapienza, P. and Zingales, L. (2008), 'Culture, Gender, and Math', *Science* **320**(5880), 1164–1165.

Hanushek, E. A. and Woessmann, L. (2020), 'The Economic Impacts of Learning Losses', *OECD* .

Kuhfeld, M., Soland, J., Lewis, K., Ruzek, E. and Johnson, A. (2022), 'The COVID-19 School Year: Learning and Recovery Across 2020-2021', *AERA Open* **8**, 23328584221099306.

Meekes, J., Hassink, W. H. J. and Kalb, G. (2023), 'Essential work and emergency childcare: Identifying gender differences in COVID-19 effects on labour demand and supply', *Oxford Economic Papers* **75**(2), 393–417.

Olden, A. and Møen, J. (2022), 'The triple difference estimator', *The Econometrics Journal* **25**(3), 531–553.

Pokhrel, S. and Chhetri, R. (2021), 'A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning', *Higher Education for the Future* **8**(1), 133–141.

Singh, A., Romero, M. and Muralidharan, K. (2022), 'COVID-19 Learning Loss and Recovery: Panel Data Evidence from India', *NBER working paper* (30552).

Villarreal, A. and Yu, W.-h. (2022), 'Research Note: Gender Differences in Employment During the COVID-19 Epidemic', *Demography* **59**(1), 13–26.

Table 1: Summary statistics

	$\Delta_{Grade5-Grade2}$				$\Delta_{Grade8-Grade5}$			
	Grade 2		Grade 5		Grade 5		Grade 8	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated
Socio-demographic characteristics								
Gender								
Boys (ref.)								
Girls	49.25%	49.38%	49.29%	49.42%	49.74%	49.45%	49.80%	49.48%
Italian-born to								
Italian-born parents	90.00%	88.75%	89.76%	88.27%	91.12%	89.88%	91.40%	90.56%
Immigrants	1.72%	1.59%	1.66%	1.86%	2.49%	2.05%	2.31%	1.97%
Born in Italy to immigrant parents	8.28%	9.66%	8.58%	9.87%	6.38%	8.08%	6.29%	7.47%
Mother's educational attainment								
Elementary education	2.00%	1.68%	1.92%	1.66%	2.25%	1.94%	2.09%	1.76%
Lower secondary education	24.85%	21.92%	24.52%	21.85%	26.99%	24.75%	26.66%	24.41%
Upper secondary education	51.20%	50.50%	51.38%	51.96%	52.17%	51.28%	52.33%	53.06%
Tertiary education	21.96%	25.90%	22.18%	24.53%	18.58%	22.03%	18.92%	20.77%
Father's educational attainment								
Elementary education	2.49%	2.15%	2.35%	2.06%	2.68%	2.38%	2.50%	2.20%
Lower secondary education	32.98%	30.08%	32.82%	29.95%	34.90%	32.97%	34.49%	32.47%
Upper secondary education	48.09%	49.87%	48.33%	50.75%	47.39%	48.26%	47.73%	49.64%
Tertiary education	16.44%	17.90%	16.50%	17.24%	15.03%	16.38%	15.28%	15.69%
Mother's occupation								
Unemployed	6.09%	6.19%	5.81%	5.91%	5.28%	5.87%	4.71%	5.20%
Stay-at-home mother	31.82%	29.30%	30.97%	26.37%	33.62%	31.84%	32.23%	24.73%
Manager, university professor, civil servant	1.27%	1.36%	1.35%	1.62%	1.24%	1.32%	1.35%	1.81%
Entrepreneur, farmer owner	2.09%	2.12%	2.18%	2.66%	2.03%	2.13%	2.17%	3.19%
Employed professional, freelancer	11.27%	12.54%	11.47%	13.36%	10.52%	11.30%	10.87%	13.06%
Self-employed worker	11.14%	10.64%	11.04%	11.81%	11.46%	10.90%	11.59%	13.88%
Teacher, white-collar worker, military leader	35.48%	37.51%	35.79%	37.14%	34.15%	35.42%	34.99%	35.73%
Blue-collar worker, employed in service industry	20.56%	21.31%	21.63%	23.85%	20.16%	20.85%	21.12%	25.82%
Retired	0.13%	0.13%	0.12%	0.15%	0.14%	0.12%	0.15%	0.25%
Father's occupation								
Unemployed	5.28%	4.72%	5.05%	4.42%	5.07%	5.27%	4.45%	4.49%
Stay-at-home father	0.53%	0.33%	0.31%	0.33%	0.41%	0.32%	0.30%	0.34%
Manager, university professor, civil servant	3.41%	3.18%	3.50%	3.46%	3.69%	3.44%	3.78%	3.66%
Entrepreneur, farmer owner	7.12%	6.79%	7.10%	7.29%	7.02%	7.02%	7.15%	7.55%
Employed professional, freelancer	18.87%	19.04%	18.87%	19.21%	18.94%	18.92%	18.83%	18.98%
Self-employed worker	26.05%	24.14%	25.61%	23.82%	27.60%	25.75%	26.91%	25.15%
Teacher, white-collar worker, military leader	32.85%	35.28%	32.62%	33.35%	31.68%	33.08%	31.91%	31.78%
Blue-collar worker, employed in service industry	41.05%	42.77%	41.70%	42.54%	39.71%	41.48%	39.82%	40.99%
Retired	0.64%	0.58%	0.71%	0.70%	0.77%	0.71%	1.07%	1.08%
Indicator of regularity with respect to studies								
Regular or early (ref.)								
Age with respect to norm for grade level	1.20%	1.16%	1.07%	1.06%	1.87%	1.81%	1.77%	1.78%
Students' test scores								
Mathematics	203.38	208.84	207.27	200.70	204.03	207.12	203.96	196.63
Reading	202.98	207.68	204.64	204.74	203.40	204.19	204.33	199.59
Observations	872,339	874,951	872,339	874,945	865,821	947,169	865,821	947,169

Notes: The table presents the mean values for socio-demographic characteristics and test scores.

Table 2: Empirical setting

Progression	Grade in $t = 0$	Grade in $t = 1$	Group	Treatment status
Grade 5 to grade 8	Grade 5 – 2018-19	Grade 8 – 2021-22	Group 2022	Treated
	Grade 5 – 2015-16	Grade 8 – 2018-19	Group 2022	Control
	Grade 5 – 2017-18	Grade 8 – 2020-21	Group 2021	Treated
	Grade 5 – 2014-15	Grade 8 – 2017-18	Group 2021	Control
Grade 2 to grade 5	Grade 2 – 2018-19	Grade 5 – 2021-22	Group 2022	Treated
	Grade 2 – 2015-16	Grade 5 – 2018-19	Group 2022	Control
	Grade 2 – 2017-18	Grade 5 – 2020-21	Group 2021	Treated
	Grade 2 – 2014-15	Grade 5 – 2017-18	Group 2021	Control

Table 3: Main results

	$\Delta_{Grade5-Grade2}$			
	Mathematics		Reading	
DID				
Average effect	-0.009**	-0.009**	-0.019***	-0.020***
	(0.004)	(0.004)	(0.004)	(0.004)
Group 2021	0.009	0.009	-0.030***	-0.030***
	(0.006)	(0.006)	(0.006)	(0.006)
Group 2022	-0.023***	-0.024***	-0.011**	-0.012**
	(0.006)	(0.006)	(0.005)	(0.005)
DDD				
Group 2022 - Group 2021	-0.032***	-0.033***	0.019***	0.018**
	(0.008)	(0.008)	(0.007)	(0.008)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,620,774	1,542,793	1,608,071	1,530,951
	$\Delta_{Grade8-Grade5}$			
	Mathematics		Reading	
DID				
Average effect	-0.029***	-0.028***	-0.035***	-0.033***
	(0.002)	(0.002)	(0.002)	(0.002)
Group 2021	-0.035***	-0.034***	-0.059***	-0.057***
	(0.003)	(0.003)	(0.003)	(0.003)
Group 2022	-0.026***	-0.026***	-0.014***	-0.012***
	(0.003)	(0.003)	(0.003)	(0.003)
DDD				
Group 2022 - Group 2021	0.010**	0.008*	0.044***	0.045***
	(0.004)	(0.004)	(0.004)	(0.004)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,746,560	1,665,646	1,732,908	1,654,527

Notes: The table presents the estimates from a difference-in-differences model and a triple difference model of the impacts of the COVID-19 pandemic on student learning. Socio-demographic controls included gender, student's origin, and parents' level of education (based on a binary indicator of whether or not least one has completed some higher education). The regression includes region fixed effects. Standard errors (shown in parentheses) are clustered at the classroom level. Significance levels: $^{*}p < 0.1,^{**}p < 0.05,^{***}p < 0.01$.

Table 4: Heterogeneity effects

	$\Delta_{Grade5-Grade2}$					
	Mathematics			Reading		
	Boys	Girls	Difference	Boys	Girls	Difference
DID						
Average effect	0.010**	-0.029***	-0.039***	0.035***	-0.075***	-0.110***
	(0.005)	(0.005)	(0.003)	(0.004)	(0.004)	(0.003)
Group 2021	-0.025***	0.045***	0.070***	0.003	-0.063***	-0.066***
	(0.006)	(0.007)	(0.005)	(0.006)	(0.006)	(0.005)
Group 2022	0.047***	-0.096***	-0.143***	0.064***	-0.088***	-0.152***
	(0.006)	(0.006)	(0.004)	(0.006)	(0.006)	(0.005)
DDD						
Group 2022 - Group 2021	0.073***	-0.140***	-0.213***	0.061***	-0.025***	-0.086***
	(0.009)	(0.009)	(0.007)	(0.008)	(0.008)	(0.007)
Observations	780,068	762,725	1,542,793	771,126	759,825	1,530,951
	$\Delta_{Grade8-Grade5}$					
	Mathematics			Reading		
	Boys	Girls	Difference	Boys	Girls	Difference
DID						
Average effect	-0.039***	-0.017***	0.022***	0.004*	-0.070***	-0.075***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
Group 2021	-0.070***	0.004	0.074***	-0.007**	-0.107***	-0.100***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
Group 2022	-0.012***	-0.040***	-0.028***	0.013***	-0.038***	-0.050***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
DDD						
Group 2022 - Group 2021	0.058***	-0.044***	-0.102***	0.020***	0.070***	0.050***
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
Observations	838,118	827,528	1,665,646	830,699	823,828	1,654,527

Notes: This table presents the estimates of the impact of the COVID-19 pandemic on student learning from a difference-in-differences model and a triple difference model. Regressions are estimated separately for boys and girls, and the difference between the two is calculated by adding an interaction term for gender. Socio-demographic controls include the student's origin and parents' level of education (based on a binary indicator of whether or not least one has completed some higher education). The regression includes region fixed effects. Standard errors (shown in parentheses) are clustered at the classroom level. $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$.

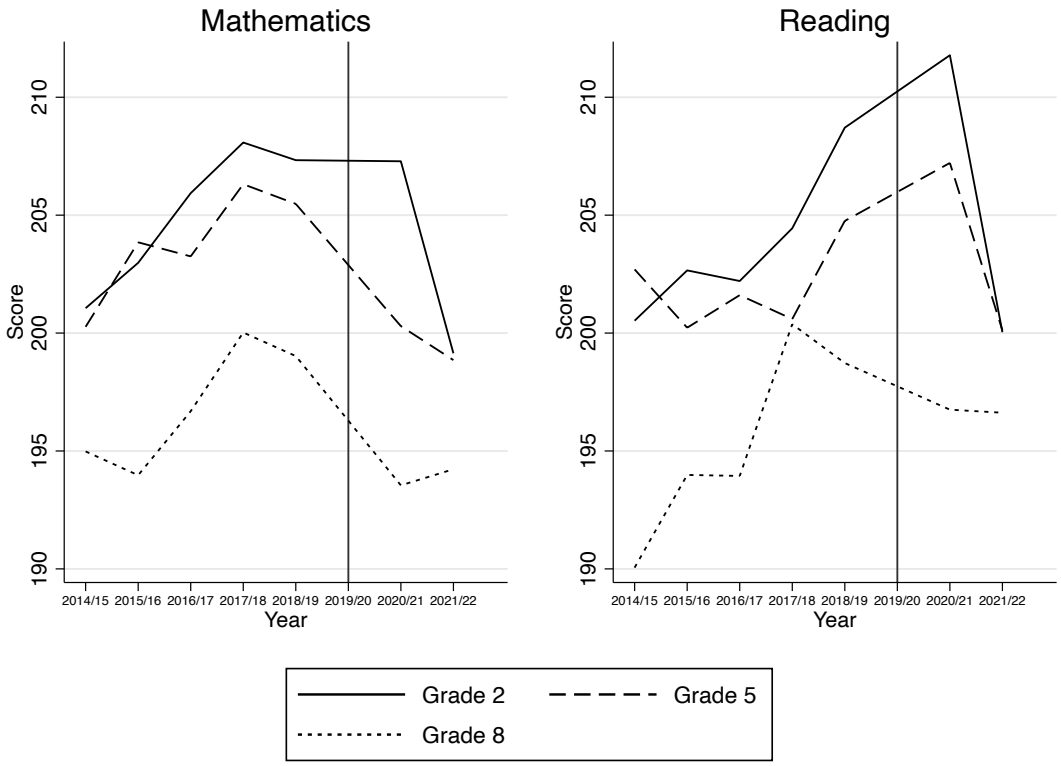
Table 5: School closure effect

	$\Delta_{Grade5-Grade2}$			
	Mathematics		Reading	
DDD	-0.083***	-0.084***	-0.063***	-0.063***
	(0.009)	(0.009)	(0.008)	(0.008)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,620,774	1,542,793	1,608,071	1,530,951
	$\Delta_{Grade8-Grade5}$			
	Mathematics		Reading	
DDD	-0.025***	-0.024***	-0.005	-0.005
	(0.005)	(0.005)	(0.004)	(0.004)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,746,560	1,665,646	1,732,908	1,654,527

Notes: This table presents the estimates of the impact of school closure duration during the COVID-19 pandemic on student learning, based on whether the number of days of closure of the school during the 2020-21 and 2021-22 school years was above or below 87, from a triple difference model. Socio-demographic controls include gender, the student's origin, and parents' level of education (if at least one has higher education). The regression includes region fixed effects. Standard errors (shown in parentheses) are clustered at the classroom level. Significance levels: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$.

Appendix

Figure A1: Score trends



Notes: The figure shows the mean mathematics and reading scores of students in grades 2, 5, and 8 over the 2014-15 to 2021-22 school years. The vertical bar in 2019-20 represents the school year when the COVID-19 pandemic began (no data collection that year).

Table A1: Main results with economic, social and cultural status

	$\Delta_{Grade5-Grade2}$			
	Mathematics		Reading	
DID				
Average effect	-0.009**	-0.012***	-0.019***	-0.021***
	(0.004)	(0.004)	(0.004)	(0.004)
Group 2021	0.009	0.006	-0.030***	-0.033***
	(0.006)	(0.006)	(0.006)	(0.006)
Group 2022	-0.023***	-0.025***	-0.011**	-0.011**
	(0.006)	(0.006)	(0.005)	(0.005)
DDD				
Group 2022 - Group 2021	-0.032***	-0.031***	0.019***	0.022***
	(0.008)	(0.008)	(0.007)	(0.008)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,620,774	1,541,096	1,608,071	1,522,221
	$\Delta_{Grade8-Grade5}$			
	Mathematics		Reading	
DID				
Average effect	-0.029***	-0.022***	-0.035***	-0.030***
	(0.002)	(0.002)	(0.002)	(0.002)
Group 2021	-0.035***	-0.034***	-0.059***	-0.058***
	(0.003)	(0.003)	(0.003)	(0.003)
Group 2022	-0.026***	-0.013***	-0.014***	-0.006**
	(0.003)	(0.003)	(0.003)	(0.003)
DDD				
Group 2022 - Group 2021	0.010**	0.021***	0.044***	0.051***
	(0.004)	(0.004)	(0.004)	(0.004)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,746,560	1,620,692	1,732,908	1,611,521

Notes: The table presents the estimates of the impact of the COVID-19 pandemic on student learning from a difference-in-differences model and a triple difference model. Sociodemographic controls include gender, the student's origin and parents' ESCS. The regression includes region fixed effects. Standard errors (shown in parentheses) are clustered at the classroom level. Significance levels: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$.

Table A2: Main results – control cohort swap

	$\Delta_{Grade5-Grade2}$			
	Mathematics		Reading	
DID				
Average effect	-0.009**	-0.009**	-0.019***	-0.020***
	(0.004)	(0.004)	(0.004)	(0.004)
Group 2021	-0.015**	-0.013**	-0.011**	-0.010*
	(0.006)	(0.006)	(0.005)	(0.005)
Group 2022	-0.009	-0.012**	-0.026***	-0.028***
	(0.006)	(0.006)	(0.005)	(0.006)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,620,774	1,542,793	1,608,071	1,530,951
	$\Delta_{Grade8-Grade5}$			
	Mathematics		Reading	
DID				
Average effect	-0.029***	-0.028***	-0.035***	-0.033***
	(0.002)	(0.002)	(0.002)	(0.002)
Group 2021	-0.024***	-0.024***	-0.023***	-0.021***
	(0.003)	(0.003)	(0.003)	(0.003)
Group 2022	-0.040***	-0.039***	-0.048***	-0.046***
	(0.003)	(0.003)	(0.003)	(0.003)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,746,560	1,665,646	1,732,908	1,654,527

Notes: The table presents the estimates of the impact of the COVID-19 pandemic on student learning from a difference-in-differences model and a triple difference model. Sociodemographic controls include gender, the student's origin and parents' level of education (if at least one has higher education). The regression includes region fixed effects. Standard errors (shown in parentheses) are clustered at the classroom level. Significance levels: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$.

Table A3: Number of school closure days by region

Region	Days
Sardinia	60
Sicily	66
Tuscany	68
Aosta Valley	68
Trentino-South Tyrol	72
Lazio	74
Umbria	76
Marche	77
Veneto	78
Abruzzo	80
Liguria	83
Emilia-Romagna	84
Piedmont	84
Lombardy	88
Molise	89
Friuli-Venezia Giulia	90
Calabria	92
Basilicata	99
Apulia	107
Campania	135

Notes: The table shows the average number of days schools in each Italian region were closed during the 2020-21 and 2021-22 school years. It is taken from Aparicio Fenoll (2022).

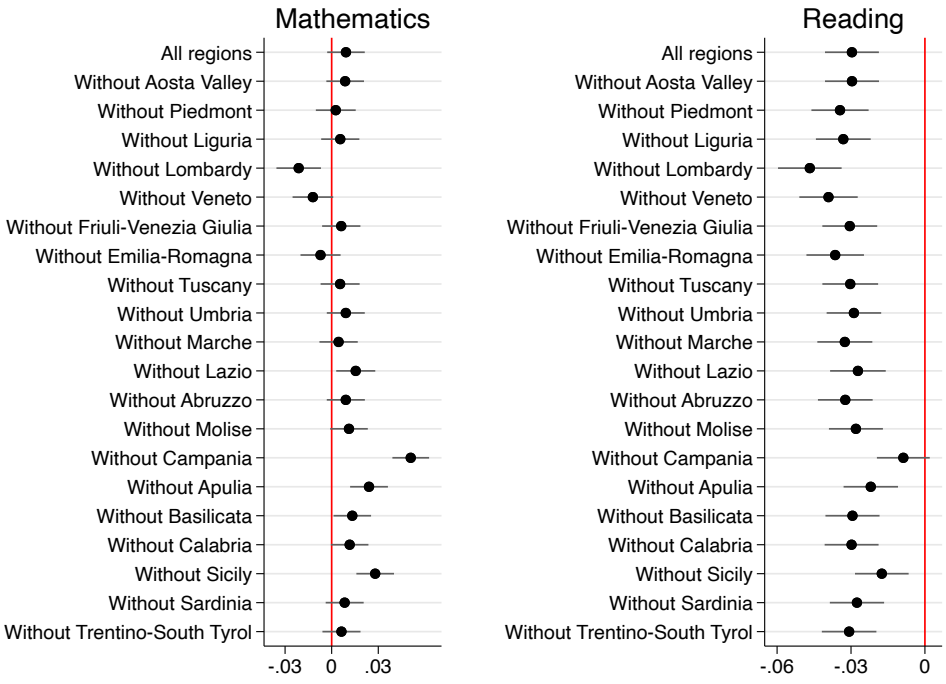
Table A4: School closure – robustness check

	$\Delta_{Grade5-Grade2}$			
	Mathematics		Reading	
DDD	-0.240***	-0.243***	-0.217***	-0.220***
	(0.015)	(0.015)	(0.014)	(0.014)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,620,774	1,542,793	1,608,071	1,530,951
	$\Delta_{Grade8-Grade5}$			
	Mathematics		Reading	
DDD	-0.127***	-0.127***	-0.049***	-0.049***
	(0.007)	(0.008)	(0.006)	(0.006)
Controls	No	Yes	No	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Observations	1,746,560	1,665,646	1,732,908	1,654,527

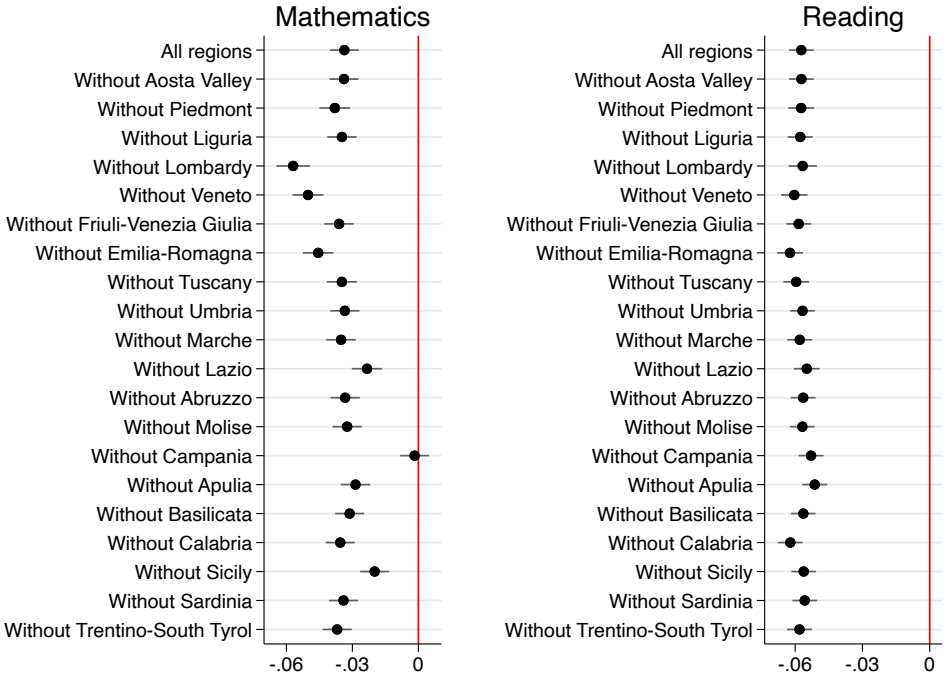
Notes: This table presents the estimates of the impact of school closure duration during the COVID-19 pandemic on student learning, based on whether the number of days of closure of the school during the 2020-21 and 2021-22 school years was above or below 99, from a triple difference model. Socio-demographic controls include gender, the student's origin, and parents' level of education (if at least one has higher education). The regression includes region fixed effects. Standard errors (shown in parentheses) are clustered at the classroom level. Significance levels: $^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$.

Figure A2: Main results by region – first pandemic year

(a) Grade 5 - Grade 2



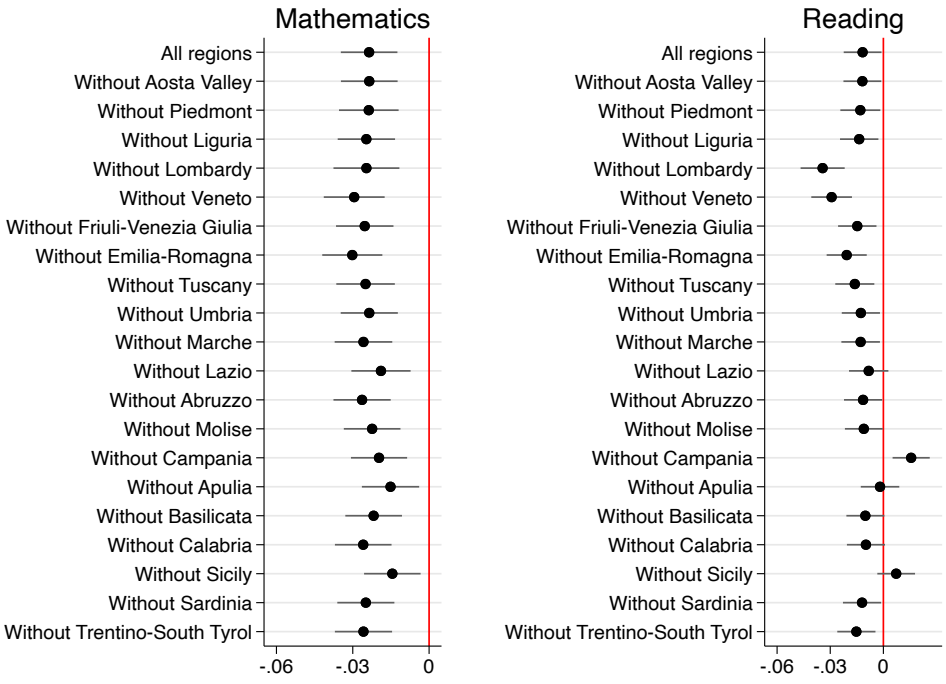
(b) Grade 8 - Grade 5



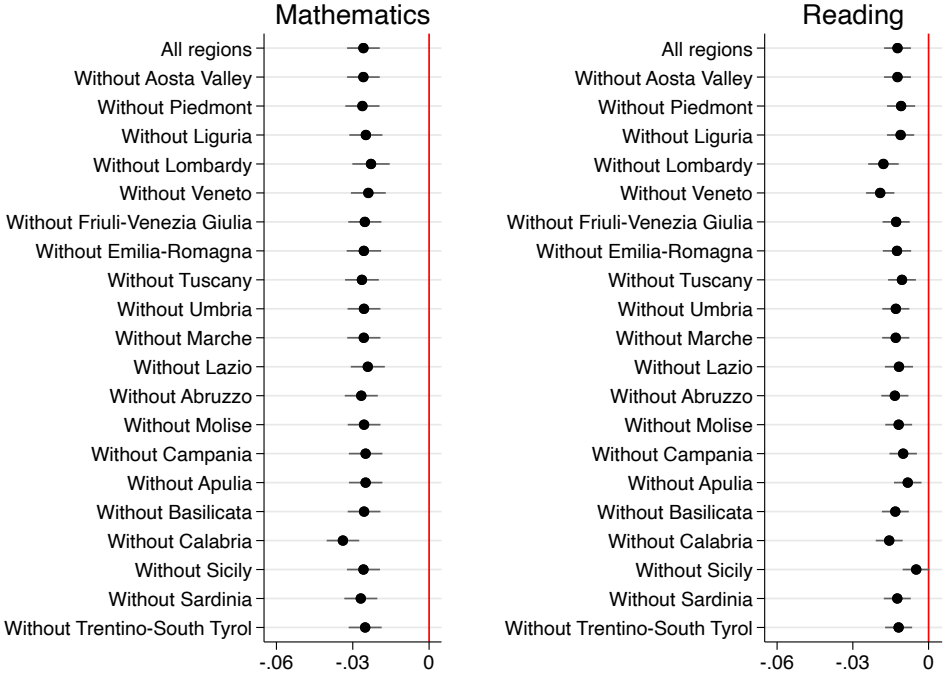
Notes: This figure presents the estimates of the impact of the COVID-19 pandemic on student learning in 2020-21 in each Italian region from a difference-in-differences model. Socio-demographic controls include gender, the student's origin and parents' level of education (if at least one has higher education). The regression includes region fixed effects.

Figure A3: Main results by region – second pandemic year

(a) Grade 5 - Grade 2



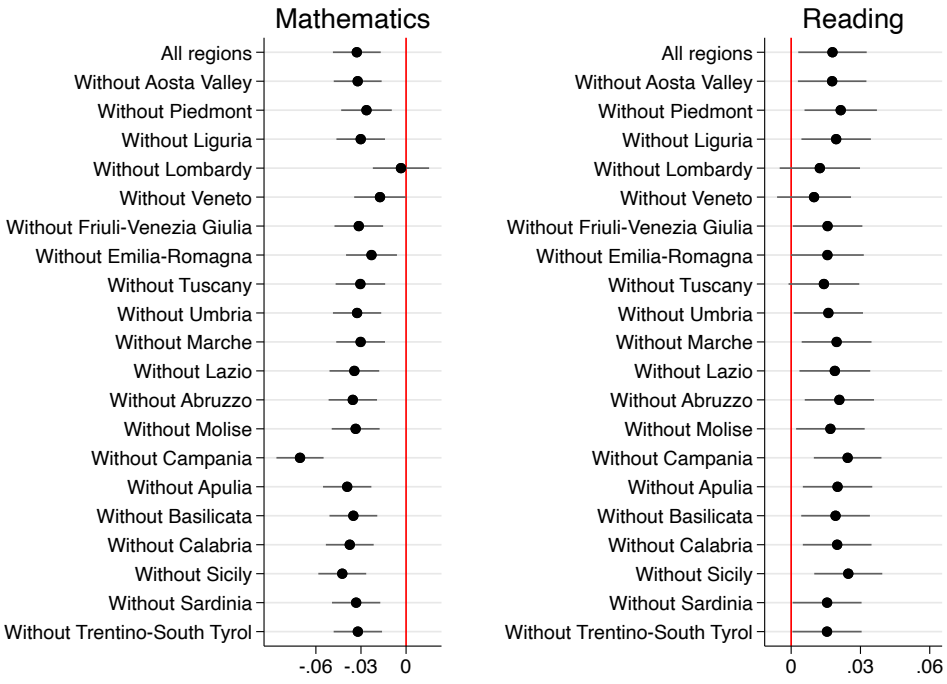
(b) Grade 8 - Grade 5



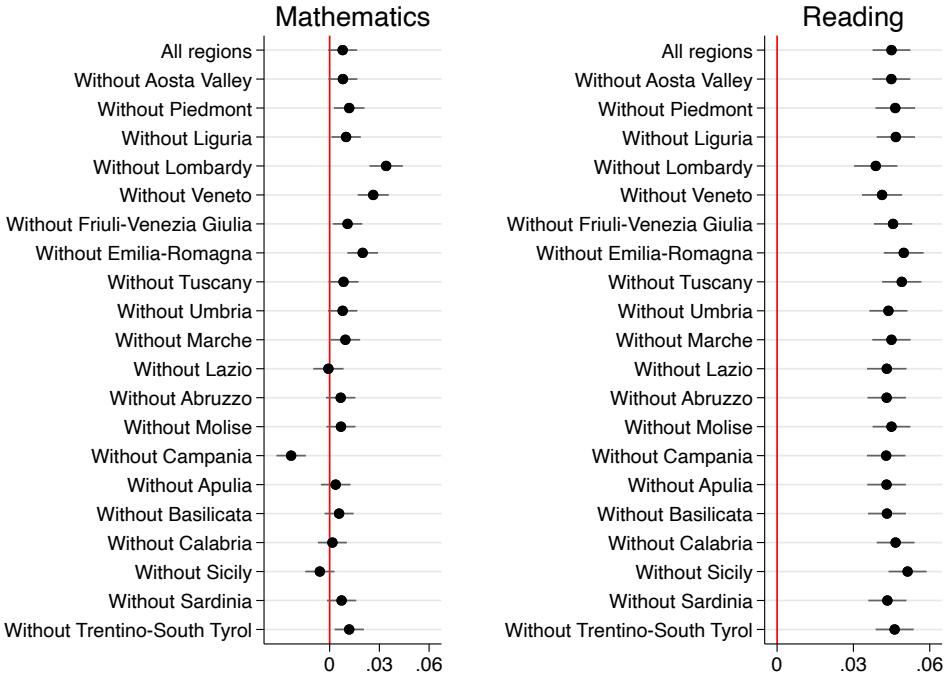
Notes: This figure presents the estimates of the impact of the COVID-19 pandemic on student learning in 2021-22 in each Italian region from a difference-in-differences model. Socio-demographic controls include gender, the student's origin and parents' level of education (if at least one has higher education). The regression includes region fixed effects.

Figure A4: Main results by region – DDD

(a) Grade 5 - Grade 2



(b) Grade 8 - Grade 5



Notes: This figure presents the estimated evolution of the impact of the COVID-19 pandemic on student learning between the 2020-21 and 2021-22 school years from a triple difference model. Socio-demographic controls include gender, the student's origin and parents' level of education (if at least one has higher education). The regression includes region fixed effects.