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The academic impact of natural disasters: evidence from L'Aquila earthquake

Abstract

This paper uses a standard difference-in-differences approach to examine the effect of the L'Aquila earthquake on the academic performance of the students of the local university. The empirical results indicate that this natural disaster reduced students' probability of graduating on-time and slightly increased students' probability of dropping out. While post-disaster measures (e.g. fast re-establishment of education activities in temporary locations) are likely to have mitigated the effects of this event, disruptions in the learning environment and the mental trauma suffered by students in the aftermath of the earthquake may have worsened their academic performance.

Keywords: L'Aquila earthquake · academic performance · difference-in-differences · on-time graduation · drop-out

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1. Introduction

Increased general public awareness about the destructive nature of natural disasters has recently trigged more research on the socio-economic consequences of these events. Nevertheless, while there are a large number of studies looking at the effect of natural disasters on economic growth (see, among others, Loayza et al. 2012; Albala-Bertrand 1993), much less attention has been paid to their impact on student achievement and progression. This is, however, an important issue. In fact, while conventional wisdom suggests that a disruption in the learning environment caused by natural disasters negatively affects students' academic performance, there is increasing evidence (Smilde-Van Den Doel et al. 2006) indicating that the direction and the magnitude of this effect are complex to evaluate as they depend on various factors. In particular, interventions in favour of the affected students in the aftermath of natural catastrophes can play an important role in this context. Students may not experience a performance decline or may experience a lesser decline if measures are taken to help them deal with post-natural disaster issues.

In this paper, we examine the effect of the L'Aquila earthquake on the academic performance of the students of the local university. During the night of 6th April 2009 the city of L'Aquila was struck by a violent earthquake that killed 309 individuals and injured about 1,600 people. Thousands of houses and buildings were seriously damaged or destroyed. About 90 percent of the residents of L'Aquila were displaced from their homes following this natural disaster. The mediaeval centre of L'Aquila, which hosts the local university, was especially hit hard. This event was one of the most expensive natural disasters in Italy's history with an estimated total economic impact of about 540 million euro (Commissariato delegato per la ricostruzione in Abruzzo 2011).

This natural disaster caused significant disruptions to students' daily life. Housing was an immediate concern. A large number of them had to relocate to cities and villages miles away

from L'Aquila. Many students moved to Avezzano, which is situated about 31 miles from L'Aquila. Additionally, about 70 percent of the infrastructure of the University of L'Aquila (including university buildings, libraries and student canteens) was closed following the earthquake (Maggiolo 2010). Though several temporary locations were found to enable students to continue their academic studies, the quality of educational programs inevitably suffered as a result of the earthquake. There was also a transportation problem as students had to travel to the new university locations. Despite efforts to return to the pre-earthquake situation, the pattern of disruption at the university continued for several years after the natural disaster. For instance, students of the Faculty of Engineering were able to return to their original university campus only in October 2013.

Perhaps more importantly, many students of the University of L'Aquila are likely to have experienced psychological problems in the aftermath of this natural catastrophe. There are many papers indicating the presence of post-traumatic stress disorder (PTSD) in survivors of natural disasters (see, for instance, Rowe and Liddle 2008; Miller 2005)[1]. PTSD symptoms include poor concentration, depression, anxiety and insomnia. In addition to PTSD, exposure to natural disasters may increase the risk of developing health issues such as cardiorespiratory and musculoskeletal problems (see, for instance, Keskinen-Rosenqvist et al. 2011). Studies on the effects of the L'Aquila earthquake are consistent with the above findings. For instance, a recent paper (Di Castelnuovo et al. 2013) compares the health status of residents of L'Aquila with the health status of people living in another region of Central Italy (i.e. Molise) in the 6 months following the earthquake. It is found that the proportion of people suffering from metabolic syndrome[2] is significantly higher among the former relative to the latter. Another study (Tempesta et al. 2013) looks at differences in sleep quality among L'Aquila citizens before and after the earthquake. The results indicate that exposure to the natural

disaster resulted in a significant deterioration of sleep quality and increased incidence of disruptive nocturnal behaviours.

Several measures were taken shortly after the L'Aquila earthquake in an attempt to mitigate some of the negative effects that this event had on students. Students were given a fee exemption for 3 academic years[3]. They were also entitled to receive discounts on study-related equipment like textbooks and computers. Additionally, to help students address transportation issues caused by relocation, they benefited from free public transport. Finally, more scholarships were awarded to students thanks to the donations of several national and international institutions.

This paper adds to previous research on the educational impact of natural disasters in three main aspects. First, while many studies look at the extent to which these events have affected student achievement at school level (see, for instance, Stein et al. 2005; Alderman et al. 2006), much less attention has been paid to this issue at university level. Second, not only are there few studies examining the effect of natural disasters on the performance of university students, but, to the best of our knowledge, none of them focus on Europe. As outlined in the next Section, existing studies analyse the academic impact of natural disasters that have occurred in New Zealand and the US. Third, this paper improves on the methodology used in these studies. While in earlier work participants have been self-selected and/or there is no control group, this paper employs a standard a difference-in-differences (DiD) approach.

We focus our attention on the impact of the L'Aquila earthquake on university drop-out and on-time graduation (i.e. within 3 years after initial enrolment). These are very important educational attainment measures, especially in Italy where a large proportion of university students abandon their studies before graduation (Schnepf 2014) and many of those who manage to complete a degree do not do this within the prescribed time (Aina et al. 2011).

The empirical strategy consists of examining the differences in drop-out and on-time graduation between students enrolled at the University of L'Aquila (the treated group) and those enrolled at other Universities located in Central Italy (the control group)[4], and then look at how these differences changed in the post-earthquake period relative to the pre-earthquake period. Through this comparison, which basically generates a DiD estimator, one is able to control for time-varying unobservables affecting drop-out and on-time graduation across students at both the University of L'Aquila and other Central Italian Universities. This strategy hinges on the assumption that in the absence of the earthquake the difference in the educational outcomes between students of the University of L'Aquila and those enrolled at other Central Italian Universities would have been the same as the one in the pre-earthquake period.

Students of other Universities located in Central Italy constitute a credible control group for three reasons. First, these students are similar to those of the University of L'Aquila in most observable characteristics. Second, in the pre-earthquake period, conditional on controls, the trend in on-time graduation across students at the University of L'Aquila is similar to that across students at other Central Italian Universities. Third, geographical proximity implies that treated and control students are embedded in the same socio-cultural-economic environment. For example, the cost of living faced by these students is similar and they also tend to share similar cultural traits.

To preview the main results, our estimates indicate that the L'Aquila earthquake decreased students' likelihood of completing their degree on-time and slightly increased students' probability of dropping out. We interpret these findings as evidence that post-disaster measures were able to mitigate but not fully compensate for the adverse effect of the earthquake on student performance.

The remainder of the paper is organised as follows. Section 2 reviews the findings of those studies investigating the effects of natural disasters on the academic performance of university students. Section 3 outlines the empirical strategy. The data used in this paper are described in Section 4. The results of the empirical analysis are presented and discussed in Section 5. Section 6 concludes.

2. Literature review

A relatively large number of studies investigate the impact of natural disasters on students' progression and attainment. However, only a few of them examine the impact that these events had on the academic performance of university students. Two papers study how earthquakes have affected the achievement of students at Canterbury University, New Zealand. The first one is by Helton et al. (2011) and looks at the effect of an earthquake that occurred in 2010. It finds that this natural disaster had a negative effect on cognition. However, one needs to be cautious about the conclusion of this study as it is based on a small sample (i.e. 18 students), participants are self-selected and no control group was used. Some of these problems are addressed in the second paper (Wilkinson et al. 2013) that compares the disruptions caused by the 2010 earthquake with those related to an earthquake that took place in 2011. Focusing on medical students, the authors find that the former had a greater impact on assessment performance relative to the latter. An explanation for this result is that, while the 2011 earthquake happened at the beginning of the academic year therefore giving students and the institution time to develop adaptive or coping strategies before exams, this did not occur with the 2010 earthquake, which took place at the end of the academic year.

Krane et al. (2007) analyse the disruptions caused by Hurricane Katrina to Tulane University School of Medicine and Louisiana State University School of Medicine at New Orleans. Following this event, these Schools were relocated to temporary locations and training for

students was re-established one month later. Hurricane Katrina seems to have had no effect on student performance. Mean final course average, standardized National Board of Medical Examiners course examination scores and scores for US Medical Licensing Examination Steps 1 and 2 were all unchanged. This result, however, contrasts with that of Watson et al. (2011) who investigate the effect of Hurricane Ilke on students of the University of Texas Medical Branch (UTMB). Using a representative sample of the UTMB student population, the authors find that about half of the respondents reported that this natural disaster had negatively affected their academic performance. A significant proportion of the students interviewed (i.e. 24 percent) considered that the size of the negative effect was 'substantial'.

In sum, the findings of these studies indicate that, though natural disasters have the potential to exert a considerable negative effect on student academic achievement, this does not always happen. Some institutions are able to handle the disruptions of the disaster relatively well, thereby mitigating or even completely offsetting the negative consequences on students' performance.

3. Empirical strategy

Data are pooled from 3 cohorts of students who enrolled at Universities located in Central Italy in 2001, 2004 and 2007. These students are tracked for up to 3/4 years after enrolment. In order to evaluate the effect of the L'Aquila earthquake on drop-out and on-time graduation, a DiD strategy is used. The first difference contrasts students of the University of L'Aquila and students enrolled at other Universities of Central Italy, assuming therefore that the latter were unaffected by the earthquake. The second difference concerns the timing of the earthquake. In the data, while students of the University of L'Aquila who started their studies in 2007 were hit by this natural disaster, those who enrolled at the same institution in 2001 and 2004 were not exposed to the earthquake. The difference in these differences can be

interpreted as the causal effect of the earthquake, under the assumption that in the absence of the earthquake, the change in the outcome measures would have not been systematically different across students at the University of L'Aquila and those at other Universities in Central Italy.

The following equation is estimated:

$$Y_{ijt} = \beta_0 + \beta_1^{'} X_{ijt} + \beta_2 Aquila_j + \beta_3 Earthquake_t + \beta_4 Aquila_j * Earthquake_t + \varepsilon_{ijt} \qquad (1)$$

where Y_{ijt} is a dichotomous variable that is equal to 1 if student i enrolled at university j in year t drops out /graduates on-time, and 0 otherwise. X is a vector of individual and family characteristics that are thought to influence these outcomes. *Aquila* is a dummy variable that takes the value 1 if the student was enrolled at the University of L'Aquila, and 0 otherwise. *Earthquake* is a dummy variable taking the value 1 if the student started university in 2007, and 0 otherwise; ε is the regression error term.

The coefficients of this DiD framework have the following interpretation. β_2 captures the average permanent differences in the outcomes between students enrolled at the University of L'Aquila and those enrolled at other Central Italian Universities. β_3 accounts for pre and post-earthquake differences that are common to both the treated and control groups. The parameter of interest is β_4. It tests whether the difference in average outcomes between students enrolled at the University of L'Aquila and those enrolled at other Central Italian Universities in the post-earthquake period is different from the same difference in the pre-earthquake period. The key identifying assumption is that β_4 would be zero in the absence of the L'Aquila earthquake. β_4 identifies the true impact of the earthquake assuming that, conditional on X, trends in student drop-out and on-time graduation between the University

of L'Aquila and other Central Italian Universities would be identical if the earthquake had not occurred.

Although our 2 outcome measures, i.e. drop-out and on-time graduation, are binary variables, Equation (1) is often estimated using a linear probability model (see, for instance, Andrews et al. 2010; Cortes et al. 2013; Dynarski 2003). While this model has some weaknesses, such as the assumption that errors are normally distributed, it has the important advantage that the interpretation of the parameter of interest is similar to that of a linear regression model. Additionally, Ai and Norton (2003) show that in nonlinear models involving dichotomous or limited variables the coefficient of the interaction term between two variables does not capture the effect of a change in both variables since the real effect comprises some cross-derivatives or differences. While our main results are obtained using a linear probability model, in a robustness check we also estimate Equation (1) using a probit model and employ the method proposed by Norton, Wang and Ai (2004) to compute the correct average marginal effect of the interaction term ('inteff' command in Stata).

4. Data

Data come from 3 waves (i.e. 2004, 2007 and 2011) of a national cross-sectional survey (*Percorsi di studio e di lavoro dei diplomati*) conducted by the Italian National Statistical Institute (ISTAT). Each wave consists of a nationally representative sample of high school leavers who were surveyed 3/4 years after successfully completing their studies. Given that one of the possible destinations of recent high school leavers is university enrolment[5], through these data it is possible to identify 3 cohorts of students who began university in 2001 (from the 2004 wave), 2004 (from the 2007 wave) and 2007 (from the 2011 wave). As the earthquake occurred in April 2009, while the 2001 and 2004 cohorts were not exposed to this natural disaster, those students of the University of L'Aquila who began their studies in

2007 were affected by it. More precisely, they were hit by the earthquake while they were in their second year of study[6].

Two measures of student outcome are employed in this study. The first is university drop-out. Unfortunately, for this analysis only data from the 2007 and 2011 waves can be used. While the 2004 wave does not provide information on the university attended for those students who had already dropped out at the time of the interview, such information is reported in later waves. The second measure is whether or not the student has successfully completed a First-level degree. Following the European framework of the Bologna Process, in 2001 the Italian higher education system embarked on a process of reform that led to the introduction of the so-called '3+2' model. This consists of a First-level degree (*Laurea di primo livello*) that lasts three years, followed by a Second-level degree (*Laurea specialistica*) of two years length. For this outcome, data from all 3 waves can be employed as the 2004 wave does give information on the university attended for those students who completed a First-level degree or were still enrolled at the time of the interview.

One issue with merging data from the 3 waves of this survey is that, while in the 2004 and 2007 waves high school leavers were surveyed 3 years after successfully completing their studies, in the 2011 wave students were contacted 4 years following the end of high school. This poses a problem in creating harmonised outcome measures as university students need to be observed for the same amount of time across each cohort. Such a problem can be easily solved with respect to our second measure of student outcome as the 2011 wave reports information on the year students successfully completed the First-level degree. Therefore, in all 3 cohorts one can observe whether the student earned a First-level degree within 3 years following his/her initial enrolment. However, what of the drop-out indicator? Given the purpose of this study, the only viable option is to see whether the student has withdrawn from

university at the end of his/her second year of study. While information on third-year drop-out is available for the 2004 cohort, this is not the case for the 2007 cohort where data do not allow us to separate third-year drop-out from fourth-year drop-out. Second-year drop-out captures the immediate effect of the earthquake on drop-out since, as mentioned above, students of the University of L'Aquila were in their second year of study when the natural disaster occurred.

The survey contains information on many individual characteristics that are likely to influence the probability of dropping out of university and the probability of earning a First-level degree within 3 years after initial enrolment. One can therefore control for gender, age, region of residence[7], type of upper secondary school (academic versus technical and private versus public), academic ability (proxied by lower and upper secondary school final marks) and parental education.

The empirical analysis in this study is based on the assumption that students in the dataset are representative of the overall student population of the University of L'Aquila and of other Italian Central Universities. A comparison can be made between our dataset and data on the population of first-year students collected by the Italian Ministry of Education, Universities and Research (MIUR). There appears to be a relatively good match between them. For instance, while the MIUR statistics indicate that the average proportion of male freshmen who enrolled at the University of L'Aquila in the academic years 2001/02, 2004/05 and 2007/08 is 42.2 percent, in our dataset the average proportion of male high school leavers enrolled at the University of L'Aquila during these academic years is 38.2 percent[8].

To construct the final samples, the following high school leavers were excluded: a) those who did not enrol at the university within 3/4 years following successful completion of their studies, b) those who enrolled at university but did not do so straight after the conclusion of

their studies[9], c) those who were living abroad at the time of the survey and d) those with missing information of interest. Table 1 reports the summary statistics for the final samples[10]. As with all of the statistics and estimates presented in the paper (apart from those shown in Appendix Table A2), these summary statistics are weighted using the survey weights. The sample used to investigate the effect of the L'Aquila earthquake on on-time graduation comprises 2,570 students. Among those students who were still enrolled at university after 3 years, 8.9 percent obtained a First-level degree. On the other hand, the drop-out sample, which only includes students from the 2004 and 2007 cohorts, consists of 2,041 individuals. Conditional on not having dropped out previously, the proportion of university students who abandoned their studies in the second year is 2.4 percent.

Insert Table 1 here

Tables 2 and 3 provide summary statistics for the control variables before and after the earthquake for students enrolled at the University of L'Aquila and those enrolled at other Italian Central Universities. In the drop-out and on-time graduation samples in the pre-earthquake period students in the treated group seem to be broadly similar to those in the control group[11]. However, in both samples in the post-earthquake period there appear to be differences with regard to lower secondary school final mark. While the proportion of students at the University of L'Aquila performing extremely well in lower secondary school is higher compared to their peers at other Italian Central Universities, the opposite occurs for the proportion of students performing less well. This may be explained by the fact that in the post-earthquake period the proportion of highly educated parents increases more among students of the University of L'Aquila than among those of other Italian Central Universities.

It is well-known in the literature that there is a positive correlation between parental education and student academic performance (see, for instance, Björklund and Salvanes 2011).

While it is important to look at post-earthquake differences between the treated and control groups, one should bear in mind that these differences cannot be attributed to this event. As stated earlier, this paper looks at the impact of the earthquake on students at the University of L'Aquila who were in their second year when this natural disaster occurred. Not only in our samples are there no students who decided to enroll at the University of L'Aquila after the earthquake, but we can also rule out spillover effects, i.e. students transferring from the University of L'Aquila to other Italian Central Universities following the earthquake.

The last columns of Tables 2 and 3 present differences between students in the treated and control groups before and after the earthquake. In the drop-out sample there are no statistically significant differences (at the 1 and 5 percent levels) in individual characteristics between the treated and control groups across the 2004 and 2007 cohorts. This provides suggestive evidence that the continuity assumption of the DiD method holds for this analysis, i.e. there is no discontinuity in the value of the control variables at the cut-off. However, for the on-time graduation analysis there is less support for the continuity assumption given that there are statistically significant differences in the proportion of students performing well and less well in lower secondary school between the treated and control groups before and after the earthquake. The reason for this cannot be determined here, but is consistent with a substantial increase in the proportion of highly educated parents among students of the University of L'Aquila in the post-earthquake period relative to the pre-earthquake period.

Insert Tables 2 and 3 here

5. Results

Table 4 presents the DiD estimates from Equation (1), which examines the effect that the L'Aquila earthquake had on the 2 university performance measures employed in this study. While the first half of Table 4 reports the drop-out findings, the second half of Table 4 presents the on-time graduation results. Robust standard errors are clustered at the university level in all regressions to account for within-university correlation in errors. However, since the analysis includes only 11 universities, there is the risk that clustering standard errors at university level may lead to too small standard errors due to a few-cluster bias. To address this problem, in Appendix Table A2 we apply the wild cluster bootstrap-t procedure to calculate alternative p-values as suggested by Cameron and Miller (2015)[12]. The results provide evidence showing that there is only a small difference between p-values using the wild-cluster bootstrap-t procedure and p-values that are adjusted for clustering at university level.

Insert Table 4 here

Column (1) of Table 4 reports the unconditional DiD estimate of the effect of the earthquake on the probability of dropping out of university immediately after the event. The result suggests that the earthquake had a small but statistically significant effect on university drop-out. Specifically, the change in the probability of dropping out of university in the second year between L'Aquila students and those enrolled at other Universities in Central Italy is approximately 3.4 percentage points higher in the post-earthquake period relative to the pre-

earthquake period. Column (2) of Table 4 shows that this estimate is robust to the inclusion of the control variables, falling a little in size (0.028), but remaining statistically significant at the 5 percent level.

Disruptions in the learning environment and the mental trauma caused by the earthquake may have induced several students of the University of L'Aquila to abandon their studies. One would have expected this event to have a greater impact on university drop-out, but it is likely to have been mitigated by the fee exemption policy.

Column (3) of Table 4 shows the unconditional DiD estimate of the effect of the earthquake on the probability of graduating on-time[13]. The result indicates that the change in the probability of on-time graduation between L'Aquila students and those enrolled at other Universities in Central Italy is about 4.7 percentage points lower in the post-earthquake period relative to the pre-earthquake period. This DiD estimate is statistically significant at the 10 percent level.

In an attempt to check the robustness of the above result, Column (4) of Table 4 gives the corresponding conditional estimate. The estimated effect of the earthquake on the probability of graduating on-time slightly changes with the inclusion of control variables: it is 6.6 percentage points, with a standard error of 2.3 percentage points[14]. It is also important to note that the addition of the covariates substantially improves the fit of the regression.

Although in this paper we are unable to identify the reasons behind the negative effect exerted by the earthquake on on-time graduation, this finding may be attributed to disruptions in the learning environment and the psychological problems from which students suffered in the aftermath of the natural disaster. It has probably taken longer than expected to graduate for those students who developed PTSD symptoms after the earthquake. Similarly, academic

and personal issues experienced by students following this event may have prevented many of them to complete the degree on-time.

Even though a number of post-disaster measures (e.g. fast re-establishment of education activities in temporary locations) may have lessened the negative effects of the earthquake on on-time graduation, the fee exemption policy combined with unfavourable labour market conditions for skilled workers have worked the opposite way. Graduates' poor job prospects after the natural disaster could have reduced students' incentives to complete their degree within the prescribed time (Brunello and Winter-Ebmer 2003). Additionally, this behaviour has no direct financial consequences given that, following the earthquake, all students of the University of L'Aquila received a fee exemption for the next 3 academic years. As shown by Garibaldi et al. (2012), a reduction in tuition fees for students enrolled beyond the minimum period does not encourage graduation within the prescribed time.

We carry out several tests to assess the robustness of the findings reported in Table 4. The results of some of these tests are shown in Table 5. First, Columns (1) and (5) of Table 5 report probit marginal effects of the interaction term using the 'inteff ' Stata command. In the on-time graduation analysis the estimated treatment effect is still negative and significant and its magnitude is quite similar to that reported in Column (4) of Table 4. Similarly, in the drop-out analysis the estimated treatment effect remains positive and significant, though its size is somewhat bigger than that obtained using the linear probability model[15]. Second, we add a 2001 student cohort dummy to our specification in the on-time graduation analysis. Column (2) of Table 5 shows that the estimated treatment effect is not significantly affected by this change. Third, we add a time trend to our specification in the on-time graduation analysis. The inclusion of the time trend again does not change our result (see Column (3) of Table 5). Fourth, we include university fixed effects in Equation (1). As reported in Columns

(4) and (6) of Table 5, the estimated treatment effects are close to those shown in Columns (4) and (2) of Table 4, respectively.

Insert Table 5 here

Table 6 considers the robustness of our results to 2 alternative control groups. We rely on the work of Cerqua and Di Pietro (2017) in the selection of these control groups. They use the synthetic control method to study how the L'Aquila earthquake affected subsequent enrolment at the local university. The synthetic control groups are constructed by selecting Italian higher education institutions 'comparable' to the University of L'Aquila in terms of size, tuition fees and student characteristics (i.e. age and gender) during the pre-earthquake period. With the first and second alternative control groups, in the on-time graduation analysis the estimated treatment effect is statistically significant at the 5 percent level and varies between -6.0 and -6.2 percentage points (see Columns (1) and (2) of Table 6). Looking at Columns (3) and (4) of Table 6, one may note that the size of the estimated effect of the earthquake on university drop-out is smaller than that found in Tables 4 and 5, but the relevant coefficient is always statistically significant at conventional levels.

Insert Table 6 here

Three different types of falsification tests are performed to check the validity of our results: 1) we conduct a placebo regression using students of the University of L'Aquila who began

their studies in 2004 as the treated group, 2) we examine whether students in the treated and control groups were following a parallel trend before the earthquake and 3) we artificially assume that the earthquake did not hit the University of L'Aquila but 'comparable' higher education institutions. While the third type of test can be carried out for both the drop-out analysis and the on-time graduation analysis, the first two types can only be run for the latter. This is because in the drop-out analysis we only have data on one student cohort before the earthquake.

First, we consider that the earthquake affected students of the University of L'Aquila who began their studies in 2004 instead of those who enrolled at this institution in 2007. For this falsification exercise, the middle cohort is chosen since it corresponds to the mid-point of the pre-earthquake period. Results are quite similar if students of the University of L'Aquila in the 2001 cohort are the ones artificially assumed to have been exposed to the earthquake. Column (1) of Table 7 reports results from the corresponding DiD model that is based on this mis-coded earthquake dummy. The DiD coefficient is found not to be statistically significant at conventional levels. Such a finding indicates that the estimated effect of the earthquake on on-time graduation is a genuine causal effect and not an artefact of the statistical approach.

Second, the identifying assumption of parallel trend in this outcome in the absence of the earthquake is examined. A similar trend in student on-time graduation across the University of L'Aquila and other Universities located in Central Italy should be observed prior to the earthquake. If this assumption is violated, then the estimated effect of the earthquake might be spurious as it could be the result of a diverging trend in on-time graduation that existed even before the occurrence of the natural disaster. To test the parallel trend assumption, Equation (1) is re-estimated using data only for the 2001 and 2004 student cohorts. The results, which are shown in the Column (2) of Table 7, indicate that in the pre-earthquake

period the student on-time graduation trend was similar across the treated and untreated universities as the coefficient on the relevant interaction term is statistically insignificant.

Third, we simulate that the earthquake hit Italian higher education institutions 'comparable' to the University of L'Aquila instead of the University of L'Aquila. For this purpose, we select two universities that made up the alternative control groups used in one of the previous robustness tests (see Table 6). It is the expectations that models based on these 'false' treated groups will yield insignificant results. In line with expectations, as shown in Columns (3), (4), (5) and (6) of Table 7, none of these models yield any significant results, reinforcing our main findings.

Insert Table 7 here

6. Conclusions

On 6th April 2009 the city of L'Aquila was hit by a violent earthquake that caused hundreds of victims and considerable damage to buildings, road and other infrastructures. This paper investigates the impact that this natural disaster had on the academic performance of the students of the local university. Not only has the earthquake led to significant disruptions in the learning environment (e.g. closure of university buildings), but students of the University of L'Aquila are likely to have suffered from physiological and psychological stress following this event.

In order to evaluate the effect of the earthquake on student academic performance, a difference-in-differences methodology is used. Changes in outcomes for students at the

University of L'Aquila before and after the earthquake are compared to changes in outcomes for students at other Central Italian Universities over the same period of time. The key identifying assumption of this approach is that trends in student outcomes across these two groups of Universities would have been identical in the absence of the earthquake.

The empirical results suggest that the L'Aquila earthquake has significantly reduced the probability that a student will graduate on-time. Specifically, the estimates indicate that this natural disaster led to a decline of between 4.7 and 6.6 percentage points in the likelihood of earning a First-level degree within 3 years of initial enrolment. There is also evidence that the L'Aquila earthquake increased students' probability of dropping out during the academic year in which this natural disaster occurred. The magnitude of the effect is, however, smaller compared to the effect on on-time graduation. Although post-disaster measures are likely to have lessened the impact of the earthquake, our results indicate that they have not completely offset the negative effects that this natural disaster had on student performance.

What lessons can be learnt from the L'Aquila earthquake? Although it is unclear the extent to which the results of this study can be generalised to other disruptions in learning, the following two considerations can be made. First, following the natural disaster and the closure of educational facilities, it is important that the hit higher education institution is able to quickly move its educational program to a new location. Not only should continuity in education be insured, but academic staff and students need a learning environment characterised by security and safety. Second, providing a fee exemption for those students affected by the natural disaster may be used in an attempt to mitigate the effect of this event on drop-out. This measure may compensate for the likely increase in the indirect costs of university education (e.g. accommodation, transportation) experienced by students following the natural disaster. On the other hand, however, the elimination of tuition fees combined

with poor employment prospects for skilled workers may reduce students' incentives to graduate on-time.

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Notes

Some papers (e.g. Carter et al. 2014) find evidence of these problems among university students.

[2] Metabolic syndrome is a cluster of conditions — increased blood pressure, high blood sugar level, excess body fat around the waist and abnormal cholesterol levels — that occur together, increasing a person's risk of heart disease, stroke and diabetes.

[3] The fee exemption was successively extended for 3 more academic years.

[4] Students enrolled at universities located in the regions of Molise, Marche and Abruzzi (apart from L'Aquila) comprise the control group.

[5] In Italy, all individuals who have successfully completed five years at any type of upper secondary school gain the automatic right to enrol at university.

[6] In Italy, the academic year runs between the beginning of October and the end of July the following year.

[7] Though the attention is here focused only on students enrolled at universities located in three regions, several of these students indicated their residence in many other different Italian regions. Some of the students may have been commuting. Additionally, university attendance is generally not compulsory in Italy.

[8] One should observe that the two groups of students being compared are not exactly the same. First-year students included in the MIUR statistics comprise also people who have decided to enrol at university several years after successfully completing high school.

[9] Students who went to university one or more years following high school completion are observed for a shorter period of time relative to those who began university immediately after the end of high school. In each wave the large majority of high school leavers (i.e. more than 85 percent) started university straight after successfully completing their studies.

[0] One concern is that the sample restrictions may have an effect on the representativeness of our final samples. To investigate this problem, we compare mean student characteristics between samples with and without restrictions (see Appendix Table A1). Only those variables for which there are no missing values in the samples without restrictions are considered. Results from a *t*-test (available upon request from the author) show that there are very few statistically significant differences at the 5 percent level (i.e. 3 out of 36).

[1] One exception is the proportion of students from academic upper secondary school (liceo), which is found to be larger at the University of L'Aquila relative to other Central Italian Universities in the drop-out sample.

[2] We use the Stata command 'clustse' (provided by Andrew Menger). However, since this command does not support weighting, regression results reported in Appendix Table A2 are unweighted. Unweighted regression results confirm that the L'Aquila earthquake reduced students' probability of graduating on-time and increased students' probability of dropping

out, though the magnitude of these effects is smaller than what is found using sampling weights.

[3] Though the statistically significant impact of the earthquake on university drop-out can potentially invalidate the DiD estimates on on-time graduation (i.e. the earthquake affected the composition of the third-year student population so that the sample of third-year students at the University of L'Aquila is not comparable with that of third-year students at other universities located in Central Italy), we argue that this is unlikely to be the case. It is in fact unclear what is the net effect of this change in the student composition on on-time graduation. Factors driving students' decision whether or not to abandon their studies following the earthquake are likely to have had opposite effects on the probability of graduating on-time, so that their combined impact may well be zero. Specifically, changes in labour demand driven by the reconstruction process could have had conflicting effects on the probability of graduating on-time depending on the students' level of academic ability. On the one hand, academically able students with potentially high probability to graduate on-time are likely to be less tempted to drop out of university in the post-earthquake period given the limited good job opportunities for them. On the other hand, the earthquake could have accelerated the decision to leave the university among students with relatively poor academic ability. These students could have remained enrolled had the earthquake not occurred, but improved labour market conditions for less skilled workers during the process of reconstruction (Di Pietro and Mora 2015) could have induced them to leave the university sooner. These students have a low probability of graduating and, conditional on graduating, a very low probability of completing their degree on-time. Data shown in Appendix Table A3 would seem to support the above arguments. Following the earthquake, the proportion of students with an upper secondary school final mark between 70 and 79 among dropouts has increased more at the

University of L'Aquila relative to the control group. The opposite has occurred for the proportion of students with an upper secondary school final mark between 90 and 100.

[4] Estimates based only on data from the 2007 and 2011 waves (available upon request from the author) show that the relevant DiD coefficient is also negative (-0.037) and marginally statistically significant (p-value=0.11).

[5] However, more recent studies (e.g. Puhani 2008) dismiss Ai and Norton's (2003) concern, arguing that the conventional interpretation of interaction effects is appropriate in the specific case of nonlinear difference-in-differences models. Hence, we also compute the standard probit marginal effects of the interaction term and the results are in line with those shown in Columns (1) and (5) of Table 5.

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Table 1: Descriptive statistics

	On-time graduation sample		Drop-out sample	
	Mean	Std. Dev.	Mean	Std. Dev.
Graduated on-time (conditional on still being enrolled after 3 years)	0.089	0.285	0.116	0.320
Dropped-out in the second year (conditional on not having dropped out in the first year)	-	-	0.024	0.154
Aquila (Enrolled at the University of L'Aquila)	0.145	0.352	0.166	0.372
male	0.371	0.483	0.385	0.487
Age				
-21 years or less	0.046	0.209	0.039	0.193
-22 years	0.847	0.360	0.866	0.341
-23 years or more	0.107	0.309	0.096	0.294
Upper secondary school final mark				
-between 60 and 69	0.191	0.393	0.197	0.398
-between 70 and 79	0.267	0.443	0.254	0.435
-between 80 and 89	0.205	0.404	0.205	0.404
-between 90 and 100	0.337	0.473	0.345	0.475
Lower secondary school final mark				
-pass	0.114	0.318	0.104	0.305
-good	0.271	0.445	0.290	0.454
-very good	0.292	0.455	0.302	0.459
-excellent	0.323	0.468	0.304	0.460
Academic upper secondary school (liceo)	0.479	0.500	0.450	0.498
Private upper secondary school	0.026	0.160	0.032	0.176
Father's highest education is university degree	0.148	0.355	0.145	0.352
Mother's highest education is university degree	0.141	0.348	0.130	0.336
Unemployment rate	17.066	7.021	15.583	6.038
Student cohort				
-2001	0.425	0.494	-	-
-2004	0.296	0.457	0.514	0.500
-2007	0.279	0.448	0.486	0.500
No. of observations	2,570		2,041	

Sampling weights used.

Table 2: Pre and post-earthquake summary statistics- On-time graduation sample

	Pre-earthquake period			Post-earthquake period			
	Other central Italian universities (1)	University of L'Aquila (2)	Difference (2)-(1) (3)	Other central Italian universities (4)	University of L'Aquila (5)	Difference (5)-(4) (6)	Difference-in-differences (6)-(3) (7)
male	0.359 (0.480)	0.378 (0.486)	0.019 (0.061)	0.379 (0.485)	0.478 (0.501)	0.099* (0.059)	0.080 (0.084)
Age							
-21 years or less	0.051 (0.221)	0.045 (0.209)	-0.006 (0.027)	0.027 (0.162)	0.066 (0.249)	0.039 (0.026)	0.045 (0.037)
-22 years	0.832 (0.374)	0.822 (0.384)	-0.010 (0.048)	0.897 (0.304)	0.863 (0.345)	-0.034 (0.037)	-0.024 (0.061)
-23 years or more	0.117 (0.322)	0.133 (0.340)	0.016 (0.042)	0.076 (0.266)	0.071 (0.258)	-0.005 (0.028)	-0.021 (0.051)
Upper secondary school final mark							
- between 60 and 69	0.177 (0.381)	0.256 (0.438)	0.079 (0.058)	0.206 (0.404)	0.172 (0.379)	-0.034 (0.046)	-0.113 (0.074)
-between 70 and 79	0.285 (0.452)	0.235 (0.425)	-0.050 (0.051)	0.246 (0.431)	0.191 (0.395)	-0.055 (0.049)	-0.005 (0.071)
-between 80 and 89	0.193 (0.395)	0.222 (0.417)	0.029 (0.054)	0.218 (0.413)	0.270 (0.446)	0.052 (0.048)	0.023 (0.073)
-between 90 and 100	0.345 (0.476)	0.286 (0.453)	-0.059 (0.051)	0.330 (0.471)	0.366 (0.483)	0.036 (0.057)	0.095 (0.077)
Lower secondary school final mark							
-pass	0.131 (0.337)	0.123 (0.330)	-0.008 (0.036)	0.078 (0.268)	0.060 (0.239)	-0.018 (0.023)	-0.010 (0.043)
-good	0.263 (0.440)	0.354 (0.479)	0.091 (0.061)	0.274 (0.446)	0.188 (0.392)	-0.086** (0.042)	-0.177** (0.074)
-very good	0.283 (0.450)	0.292 (0.456)	0.009 (0.056)	0.330 (0.471)	0.222 (0.417)	-0.108** (0.045)	-0.117 (0.072)
-excellent	0.324 (0.468)	0.230 (0.422)	-0.094* (0.051)	0.318 (0.466)	0.530 (0.501)	0.212*** (0.058)	0.306*** (0.077)
Academic upper secondary school (liceo)	0.477 (0.500)	0.475 (0.501)	-0.002 (0.062)	0.484 (0.500)	0.481 (0.501)	-0.003 (0.059)	-0.001 (0.086)
Private upper secondary school	0.025 (0.158)	0.034 (0.181)	0.009 (0.022)	0.027 (0.163)	0.016 (0.125)	-0.011 (0.010)	-0.020 (0.024)
Father's highest education is university degree	0.149 (0.356)	0.121 (0.327)	-0.028 (0.041)	0.154 (0.361)	0161 (0.369)	0.007 (0.048)	0.035 (0.063)
Mother's highest education is university degree	0.144 (0.351)	0.125 (0.332)	-0.019 (0.037)	0.127 (0.333)	0.196 (0.398)	0.069 (0.053)	0.088 (0.064)
Student cohort							
-2001	0.602 (0.490)	0.508 (0.501)	-0.094 (0.061)	-	-	-	0.094 (0.061)
-2004	0.398 (0.490)	0.492 (0.501)	0.094 (0.061)	-	-	-	-0.094 (0.061)
-2007	-	-		1.000 (0.000)	1.000 (0.000)	0.000	-
No. of observations	1,438	192	1,630	797	143	940	2,570

Sampling weights used; In Columns (1), (2), (4) and (5) standard deviations are in brackets. In Columns (3), (6) and (7) robust standard errors are in brackets.

*** statistically significant at 1%

** statistically significant at 5%

* statistically significant at 10%

Table 3: Pre and post-earthquake summary statistics-Drop-out sample

	Pre-earthquake period			Post-earthquake period			
	Other central Italian universities	University of L'Aquila	Difference (2)-(1)	Other central Italian universities	University of L'Aquila	Difference (5)-(4)	Difference-in-differences (6)-(3)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
male	0.375	0.350	-0.025	0.381	0.495	0.114**	0.139*
	(0.484)	(0.478)	(0.051)	(0.486)	(0.502)	(0.057)	(0.076)
Age							
-21 years or less	0.046	0.041	-0.005	0.026	0.061	0.035	0.040
	(0.210)	(0.199)	(0.025)	(0.160)	(0.241)	(0.024)	(0.035)
-22 years	0.848	0.835	-0.013	0.893	0.857	-0.036	-0.023
	(0.359)	(0.372)	(0.039)	(0.310)	(0.352)	(0.036)	(0.053)
-23 years or more	0.106	0.124	0.018	0.081	0.082	0.001	-0.017
	(0.308)	(0.330)	(0.032)	(0.273)	(0.275)	(0.028)	(0.043)
Upper secondary school final mark							
- between 60 and 69	0.198	0.137	-0.061	0.213	0.169	-0.044	0.017
	(0.399)	(0.345)	(0.039)	(0.410)	(0.376)	(0.044)	(0.059)
-between 70 and 79	0.270	0.245	-0.025	0.244	0.226	-0.018	0.007
	(0.444)	(0.431)	(0.044)	(0.430)	(0.420)	(0.050)	(0.067)
-between 80 and 89	0.184	0.201	0.017	0.216	0.264	0.048	0.031
	(0.387)	(0.402)	(0.042)	(0.412)	(0.442)	(0.046)	(0.062)
-between 90 and 100	0.348	0.418	0.070	0.326	0.341	0.015	-0.055
	(0.477)	(0.495)	(0.056)	(0.469)	(0.476)	(0.055)	(0.078)
Lower secondary school final mark							
-pass	0.123	0.139	0.016	0.082	0.079	-0.003	-0.019
	(0.329)	(0.347)	(0.036)	(0.274)	(0.270)	(0.029)	(0.047)
-good	0.325	0.248	-0.077*	0.275	0.219	-0.056	0.021
	(0.469)	(0.433)	(0.046)	(0.447)	(0.415)	(0.043)	(0.063)
-very good	0.295	0.293	-0.002	0.330	0.209	-0.121***	-0.119*
	(0.456)	(0.457)	(0.048)	(0.470)	(0.408)	(0.043)	(0.064)
-excellent	0.256	0.321	0.065	0.313	0.493	0.180***	0.115
	(0.437)	(0.468)	(0.056)	(0.464)	(0.502)	(0.040)	(0.080)
Academic upper secondary school (liceo)	0.410	0.526	0.116**	0.478	0.448	-0.030	-0.146*
	(0.492)	(0.501)	(0.055)	(0.500)	(0.499)	(0.058)	(0.080)
Private upper secondary school	0.039	0.023	-0.016	0.030	0.015	-0.015	0.001
	(0.194)	(0.149)	(0.018)	(0.171)	(0.121)	(0.010)	(0.020)
Father's highest education is university degree	0.144	0.103	-0.041	0.153	0.150	-0.003	0.038
	(0.352)	(0.305)	(0.031)	(0.361)	(0.358)	(0.045)	(0.055)
Mother's highest education is university degree	0.114	0.166	0.052	0.128	0.182	0.054	0.002
	(0.317)	(0.373)	(0.036)	(0.335)	(0.388)	(0.050)	(0.062)
No. of observations	905	152	1,057	832	152	984	2,041

Sampling weights used; In Columns (1), (2), (4) and (5) standard deviations are in brackets. In Columns (3), (6) and (7) robust standard errors are in brackets.

*** statistically significant at 1%

** statistically significant at 5%

* statistically significant at 10%

Table 4: Effect of the L'Aquila earthquake on academic performance: LPM DiD estimates

Dependent variable	Drop-out		On-time graduation	
	(1)	(2)	(3)	(4)
Constant	0.024***	0.062**	0.070***	-0.046
	(0.007)	(0.021)	(0.016)	(0.051)
Earthquake (cohort of students enrolled at the time of the L'Aquila earthquake, i.e. 2007 cohort)	-0.006	-0.003	0.084***	0.082***
	(0.010)	(0.011)	(0.024)	(0.022)
Aquila (Enrolled at the University of L'Aquila)	0.001	0.012	-0.017	0.040**
	(0.007)	(0.007)	(0.016)	(0.018)
Earthquake*Aquila	0.034***	0.028**	-0.047*	-0.066**
	(0.010)	(0.009)	(0.024)	(0.023)
male		0.004		-0.028**
		(0.004)		(0.010)
Age (omitted is 23 years or more)				
-21 years or less		-0.050**		-0.033
		(0.018)		(0.041)
-22 years		-0.024		-0.050
		(0.017)		(0.030)
Upper secondary school final mark (omitted is between 60 and 69)				
-between 70 and 79		-0.025		0.001
		(0.018)		(0.013)
-between 80 and 89		-0.046***		0.027
		(0.014)		(0.030)
-between 90 and 100		-0.037**		0.082**
		(0.016)		(0.027)
Lower secondary school final mark (omitted is pass)				
-good		-0.011		0.005
		(0.020)		(0.018)
-very good		-0.021		0.018
		(0.021)		(0.026)
-excellent		-0.017		0.054**
		(0.022)		(0.022)
Academic upper secondary school (liceo)		-0.018**		-0.011
		(0.008)		(0.017)
Private upper secondary school		0.035		0.025
		(0.041)		(0.068)
Father's highest education is university degree		0.011		-0.001
		(0.009)		(0.022)
Mother's highest education is university degree		-0.014		-0.008
		(0.010)		(0.022)
Dummies for region of residence	No	Yes	No	Yes
R squared	0.003	0.045	0.017	0.074
No. of observations	2,570	2,570	2,041	2,041

Sampling weights used. Robust standard errors in brackets are clustered at university level.
*** statistically significant at 1%
** statistically significant at 5%
* statistically significant at 10%

Table 5: Robustness checks- alternative estimation technique/alternative specifications

Dependent variable	On-time graduation				Drop-out	
	Probit	LPM	LPM	LPM	Probit	LPM
	(1)	(2)	(3)	(4)	(5)	(6)
Earthquake (cohort of students enrolled at the time of the L'Aquila earthquake, i.e. 2007 cohort)	0.076*** (0.017)	-0.054** (0.023)	-0.002 (0.031)	0.077*** (0.023)	-0.003 (0.007)	-0.004 (0.011)
Aquila (enrolled at the University of L'Aquila)	0.040 (0.032)	0.042** (0.018)	0.042** (0.018)	0.032** (0.011)	0.011 (0.008)	0.005 (0.006)
Earthquake* Aquila	-0.051** (0.025)	-0.066** (0.023)	-0.066** (0.023)	-0.062** (0.025)	0.039** (0.020)	0.028*** (0.009)
Time trend	No	No	Yes	No	-	-
2001 student cohort	No	Yes	No	No	-	-
University fixed effects	No	No	No	Yes	No	Yes
No. of observations	2,570	2,570	2,570	2,570	2,041	2,041

Sampling weights used. Robust standard errors in brackets are clustered at university level. All regressions include the following control variables: gender, age, upper secondary school final mark, lower secondary school final mark, father's and mother's highest education is university degree, academic upper secondary school (liceo), private upper secondary school and region of residence.

*** statistically significant at 1%

** statistically significant at 5%

* statistically significant at 10%

Table 6: Robustness checks- alternative control groups

Dependent variable	On-time graduation		Drop-out	
	First alternative control group	Second alternative control group	First alternative control group	Second alternative control group
	(1)	(2)	(3)	(4)
Earthquake (cohort of students enrolled at the time of the L'Aquila earthquake, i.e. 2007 cohort)	0.067*** (0.017)	0.066*** (0.014)	0.010** (0.004)	0.011** (0.004)
Aquila (enrolled at the University of L'Aquila)	-0.057 (0.092)	-0.063 (0.088)	0.024 (0.013)	0.007 (0.025)
Earthquake* Aquila	-0.062** (0.021)	-0.060** (0.019)	0.012** (0.005)	0.010** (0.005)
No. of observations	3,223	3,494	2,493	2,726

Sampling weights used. Robust standard errors in brackets are clustered at university level. All regressions include the following control variables: gender, age, upper secondary school final mark, lower secondary school final mark, father's and mother's highest education is university degree, academic upper secondary school (liceo), private upper secondary school and region of residence. The first alternative control group is composed by the University of Perugia, University of Parma, University of Urbino, University of Venice, University of Ancona and University of Pavia. The second alternative control group is made by all Universities of the first alternative control group plus University of Basilicata.

*** statistically significant at 1%

** statistically significant at 5%

* statistically significant at 10%

Table 7: Falsification tests

Dependent variable	On-time graduation				Drop-out	
	Placebo test	Parallel trend assumption	First 'false' treated group	Second 'false' treated group	First 'false' treated group	Second 'false' treated group
	(1)	(2)	(3)	(4)	(5)	(6)
2004 student cohort	0.010	0.058***				
	(0.014)	(0.016)				
Aquila (Enrolled at the University of L'Aquila)	0.021	0.038**				
	(0.014)	(0.014)				
False treated group			-0.042*	0.310***	0.041*	-0.056
			(0.023)	(0.033)	(0.020)	(0.074)
2004 student cohort*Aquila	-0.008	-0.042				
	(0.015)	(0.027)				
Earthquake (cohort of students enrolled at the time of the L'Aquila earthquake, i.e. 2007 cohort)			0.071***	0.068***	0.001	0.001
			(0.020)	(0.020)	(0.010)	(0.011)
Earthquake* 'false' treated group			0.009	-0.015	0.015	-0.004
			(0.022)	(0.020)	(0.014)	(0.011)
No. of observations	2,570	1,630	2,841	3,118	2,274	2,415

Sampling weights used. Robust standard errors in brackets are clustered at university level. All regressions include the following control variables: gender, age, upper secondary school final mark, lower secondary school final mark, father's and mother's highest education is university degree, academic upper secondary school (liceo), private upper secondary school and region of residence. The first 'false' treated group is composed by students enrolled at the University of Basilicata. The second 'false' treated group is made by students enrolled at the University of Venice.

*** statistically significant at 1%

** statistically significant at 5%

* statistically significant at 10%

Annex

Table A1: Descriptive statistics - Final Sample vs Original Sample

	On-time graduation sample		Drop-out sample	
	Final sample	Original sample	Final sample	Original sample
Graduated on-time (conditional on still being enrolled after 3 years)	0.089 (0.285)	0.079 (0.269)	0.116 (0.320)	0.103 (0.304)
Dropped-out in the second year (conditional on not having dropped out in the first year)	-	-	0.024 (0.154)	0.022 (0.148)
Aquila (Enrolled at the University of L'Aquila)	0.145 (0.352)	0.150 (0.357)	0.166 (0.372)	0.167 (0.373)
male	0.371 (0.483)	0.383 (0.486)	0.385 (0.487)	0.396 (0.489)
Age				
-21 years or less	0.046 (0.209)	0.051 (0.221)	0.039 (0.193)	0.047 (0.211)
-22 years	0.847 (0.360)	0.819 (0.385)	0.866 (0.341)	0.832 (0.374)
-23 years or more	0.107 (0.309)	0.129 (0.336)	0.096 (0.294)	0.121 (0.327)
Upper secondary school final mark				
-between 60 and 69	0.191 (0.393)	0.213 (0.410)	0.197 (0.398)	0.214 (0.410)
-between 70 and 79	0.267 (0.443)	0.265 (0.441)	0.254 (0.435)	0.259 (0.438)
-between 80 and 89	0.205 (0.404)	0.203 (0.402)	0.205 (0.404)	0.204 (0.403)
-between 90 and 100	0.337 (0.473)	0.320 (0.466)	0.345 (0.475)	0.324 (0.468)
Lower secondary school final mark				
-pass	0.114 (0.318)	0.128 (0.335)	0.104 (0.305)	0.112 (0.315)
-good	0.271 (0.445)	0.271 (0.445)	0.290 (0.454)	0.293 (0.455)
-very good	0.292 (0.455)	0.295 (0.455)	0.302 (0.459)	0.306 (0.461)
-excellent	0.323 (0.468)	0.306 (0.461)	0.304 (0.460)	0.289 (0.453)
Academic upper secondary school (liceo)	0.479 (0.500)	0.458 (0.498)	0.450 (0.498)	0.431 (0.495)
Student cohort				
-2001	0.425 (0.494)	0.419 (0.493)	-	-
-2004	0.296 (0.457)	0.292 (0.455)	0.514 (0.500)	0.500 (0.500)
-2007	0.279 (0.448)	0.289 (0.454)	0.486 (0.500)	0.500 (0.500)
No. of observations	2,570	3,095	2,041	2,447

Sampling weights used.

Table A2: Effect of the L'Aquila earthquake on academic performance: LPM DiD estimates (p-values using clustered standard errors vs p-values using wild-clustered bootstrapped standard errors)

Dependent variable	Drop-out		On-time graduation	
	(1)	(2)	(3)	(4)
Constant	0.028 (0.006) [0.001] {0.000}	0.049 (0.012) [0.002] {0.005}	0.079 (0.017) [0.001] {0.000}	0.990 (0.038) [0.000] {0.000}
Earthquake (cohort of students enrolled at the time of the L'Aquila earthquake, i.e. 2007 cohort)	-0.002 (0.009) [0.795] {0.740}	-0.002 (0.010) [0.878] {0.819}	0.056 (0.009) [0.000] {0.000}	0.055 (0.010) [0.000] {0.000}
Aquila (Enrolled at the University of L'Aquila)	-0.001 (0.006) [0.836] {0.938}	0.007 (0.006) [0.281] {0.286}	-0.006 (0.017) [0.717] {0.706}	0.021 (0.011) [0.086] {0.057}
Earthquake*Aquila	0.022 (0.009) [0.033] {0.000}	0.018 (0.009) [0.084] {0.101}	-0.017 (0.009) [0.089] {0.066}	-0.027 (0.008) [0.006] {0.001}
Control variables	No	Yes	No	Yes
No. of observations	2,041	2,041	2,570	2,570

Robust standard errors in brackets are clustered at university level. Regressions shown in columns (2) and (4) include the following control variables: gender, age, upper secondary school final mark, lower secondary school final mark, father's and mother's highest education is university degree, academic upper secondary school (liceo), private upper secondary school and region of residence. The numbers in square brackets indicate the estimated p-values that are adjusted for clustering at university level. The numbers in braces indicate the estimated p-values using the wild-cluster bootstrap-t procedure (2,500 replications).

Table A3: Pre and post-earthquake summary statistics-Drop-out

	Pre-earthquake period			Post-earthquake period			
	Other central Italian universities	University of L'Aquila	Difference (2)-(1)	Other central Italian universities	University of L'Aquila	Difference (5)-(4)	Difference-in-differences (6)-(3)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
male	0.567 (0.506)	0.626 (0.559)	0.060 (0.306)	0.477 (0.512)	0.643 (0.518)	0.167 (0.264)	0.106 (0.404)
Age							
-21 years or less	0.000 (0.000)	0.000 (0.000)	0	0.000 (0.000)	0.000 (0.000)	0	0
-22 years	0.829 (0.385)	0.546 (0.575)	-0.283 (0.283)	0.670 (0.482)	0.703 (0.494)	0.033 (0.235)	0.316 (0.368)
-23 years or more	0.171 (0.385)	0.454 (0.575)	0.283 (0.283)	0.330 (0.482)	0.297 (0.494)	-0.033 (0.235)	-0.316 (0.368)
Upper secondary school final mark							
-between 60 and 69	0.510 (0.510)	0.454 (0.575)	-0.056 (0.295)	0.574 (0.507)	0.170 (0.406)	-0.404* (0.212)	-0.348 (0.363)
-between 70 and 79	0.212 (0.417)	0.000 (0.000)	-0.212* (0.107)	0.228 (0.430)	0.830 (0.406)	0.602*** (0.201)	0.814*** (0.228)
-between 80 and 89	0.108 (0.317)	0.000 (0.000)	-0.108* (0.055)	0.070 (0.262)	0.000 (0.000)	-0.070 (0.049)	0.038 (0.074)
-between 90 and 100	0.169 (0.383)	0.546 (0.575)	0.377 (0.281)	0.127 (0.342)	0.000 (0.000)	-0.127 (0.076)	-0.504* (0.291)
Lower secondary school final mark							
-pass	0.190 (0.400)	0.224 (0.481)	0.034 (0.235)	0.271 (0.456)	0.427 (0.534)	0.156 (0.287)	0.122 (0.371)
-good	0.528 (0.510)	0.230 (0.486)	-0.298 (0.250)	0.389 (0.500)	0.528 (0.539	0.139 (0.291)	0.437 (0.383)
-very good	0.189 (0.399)	0.374 (0.559)	0.185 (0.298)	0.205 (0.414)	0.045 (0.225)	-0.160 (0.122)	-0.345 (0.322)
-excellent	0.093 (0.297)	0.172 (0.436)	0.079 (0.180)	0.135 (0.350)	0.000 (0.000)	-0.135 (0.099)	-0.214 (0.206)
Academic upper secondary school (liceo)	0.266 (0.451)	0.402 (0.566)	0.136 (0.280)	0.234 (0.434)	0.000 (0.000)	-0.234* (0.128)	-0.370 (0.308)
Private upper secondary school	0.099 (0.305)	0.000 (0.000)	-0.099 (0.090)	0.170 (0.385)	0.000 (0.000)	-0.170 (0.112)	-0.071 (0.144)
Father's highest education is university degree	0.083 (0.281)	0.374 (0.559)	0.291 (0.292)	0.204 (0.413)	0.000 (0.000)	-0.204* (0.118)	-0.495 (0.315)
Mother's highest education is university degree	0.000 (0.000)	0.000 (0.000)	0	0.204 (0.413)	0.000 (0.000)	-0.204* (0.118)	-0.204* (0.118)
No. of observations	25	4	29	21	7	28	57

Sampling weights used. In Columns (1), (2), (4) and (5) standard deviations are in brackets. In Columns (3), (6) and (7) robust standard errors are in brackets.

*** statistically significant at 1%

** statistically significant at 5%

* statistically significant at 10%