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Natural disasters and university enrolment: Evidence from L'Aquila earthquake

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Abstract: Although there are several studies looking at the effect of natural disasters on economic growth, less attention has been dedicated to their impact on educational outcomes, especially in more developed countries. We use the synthetic control method to examine how the L'Aquila earthquake affected subsequent enrolment at the local university. This issue has wide economic implications as the University of L'Aquila made a large contribution to the local economy before the earthquake. Our results indicate that the earthquake had no statistically significant effect on first-year enrolment at the University of L'Aquila in the three academic years after the disaster. This natural disaster, however, caused a compositional change in the first-year student population, with a substantial increase in the number of students aged 21 or above. This is likely to have been driven by post-disaster measures adopted in order to mitigate the expected negative effects on enrolment triggered by the earthquake.

Keywords: university enrolment, natural disaster, synthetic control method, post-disaster measures

JEL Classification: A20, H84, C23

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1. Introduction

A relatively large number of studies examine the economic impact of natural disasters (see, for instance, Bui et al. 2014; Skidmore and Toya 2002). Given the destructive nature of these events, it is argued that they may have several negative consequences. First, the destruction of physical and human capital stock may have a detrimental effect on economic growth. Second, firms and individuals may not be willing to invest in the affected area as they may perceive that this may be hit again by a similar environmental shock. Third, natural disasters may determine a significant exodus of people from the affected area with negative consequences on the local economy.

In this paper, we look at another channel through which natural disasters may negatively impact the local economy. This happens when these events damage the local university that is a primary contributor of the affected area's economy. The potential future decline in enrolment may cause a significant adverse effect as less spending would be injected into the local economy by the student population (in terms, for instance, of tuition fees and subsistence expenditure). Additional economic losses may occur in the long-term as declining enrolment could mean that fewer students would remain to work in the local area after graduation.

We focus our attention on the L'Aquila earthquake, and we attempt to identify the impact that this event had on subsequent first-year enrolment at the local university[1]. This issue has considerable policy implications given that before the earthquake university students were making an important contribution to the economy of the city of L'Aquila. The number of university students increased by 60% between 2000 and 2008 and they accounted for a

[1] The L'Aquila earthquake was a sudden unexpected shock. L'Aquila is not an area particularly prone to earthquakes. Prior to 2009, the last year L'Aquila was struck by an earthquake was in 1958.

significant part of the L'Aquila population[2]. These students provided jobs, rental income and demand for local goods and services (OECD 2009). It has been estimated that just before the earthquake the total expenditure generated by them, including lodging and transportation, was 220 million euro per year, which accounted for about 16% of the value added of the city of L'Aquila (http://www.oecd.org/regional/regional-policy/43226147.pdf).

To evaluate the effect of the earthquake on first-year enrolment at the University of L'Aquila one needs to estimate how first-year enrolment at this institution would have evolved in the absence of this natural disaster. Following the approach of Abadie et al. (2010), in order to construct this counterfactual, we create a synthetic control using a weighted combination of Italian universities of similar size and structure that were unaffected by the earthquake. These institutions are selected on the basis of their similarity to the University of L'Aquila in the pre-earthquake period, both with respect to relevant covariates and past realizations of the outcome.

While the synthetic control approach has been already employed to assess the effects of natural disasters, previous studies have looked at the impact that these events had on economic growth (Cavallo et al. 2013; Barone and Mocetti 2014). This paper extends the use of this methodology within the natural disasters literature to examine the effect caused by these events on first-year university enrolment.

The remainder of the paper is as follows. Section 2 provides information about the L'Aquila earthquake and its effects on the local university. Additionally, it discusses how, following this disaster, enrolment at the University of L'Aquila might have changed also in light of the measures taken to mitigate the likely negative effects of the earthquake. Section 3 outlines the

[2] In the pre-earthquake period approximately 8,000-10,000 university students were residing in the city of L'Aquila out of a population of about 70,000-80,000 inhabitants (OECD 2013).

methodology and describes the data. Section 4 presents and discusses the empirical results. Section 5 concludes and draws out some lessons that are relevant for those who are concerned about how to alleviate the impact of natural disasters on educational institutions and students.

2. Background information and related literature

On 6 April 2009 a severe earthquake of magnitude 6.3 shook the city of L'Aquila, which is situated about 70 miles northeast of Rome. This event killed 309 people[3], injured more than 1,500 individuals, and caused widespread damage and destruction. Approximately 90% of the residents of L'Aquila were displaced from their homes following this natural disaster and much of the city historical centre was declared unsafe[4]. The local university was no exception to this devastation, in terms of infrastructural damage and disruptions to students' daily life. About 70% of the infrastructure of the University of L'Aquila (including university buildings, libraries and student canteens) was seriously damaged and had to be closed for repair[5]. Lectures and exams were moved to temporary venues often located miles away from L'Aquila. This caused a significant burden on students who, not only were forced to find a new place to live[6], but also faced transportation problems as they had to travel to university temporary locations.

[3] This makes the L'Aquila earthquake the deadliest earthquake to hit Italy since the 1980 Irpinia earthquake.
[4] However, one should note that this event has not led to a significant migration out of L'Aquila. The large majority of people made homeless by the earthquake were able to find an accommodation in an area belonging to the province of L'Aquila.
[5] Aprile 2009 - Aprile 2010: l'Università dell'Aquila un anno dopo il terremoto, 28/03/2010, Retrieved February 2, 2015, from http://www.studenti.it/universita/inchieste/universita-aquila-un-anno-dopo-il-terremoto.php.
[6] The historical centre of the city of L'Aquila hosted almost one-third of the students of the University of L'Aquila before the earthquake (OECD 2009).

Despite the 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 returned to the original university site only in October 2013).

However, the supply of courses offered by the University of L'Aquila remained practically unchanged after the earthquake. The university, indeed, continued to have nine Faculties: Biotechnology, Economics, Engineering, Arts and Philosophy, Medicine and Surgery, Psychology, Education, Sport Sciences and Mathematical, Physical and Natural Sciences.

Several measures were taken shortly after the L'Aquila earthquake. They were designed both to mitigate the detrimental effects that this event exerted on current students and to make the university more attractive to prospective students. A tuition fee exemption for the next three academic years was given to existing students and was also offered to future students[7]. All students were also entitled to receive discounts on study-related materials (e.g. textbooks, computers). Furthermore, to assist students with transportation due to relocation issues, they benefited from free public transport. At the same time, the University of L'Aquila, in order to help students study anywhere at any time, developed an effective virtual learning environment (VLE). This allowed students to have online access to learning resources and to easily interact with their tutors as well as with their fellow students.

This paper is related to the literature investigating the factors that influence a student's decision about where to study. With this literature in mind, it is difficult to determine a priori the direction and the degree of the effect that the earthquake had on first-year enrolment at the University of L'Aquila. Measures adopted following this natural disaster could have offset the expected negative effect on first-year enrolment caused by the earthquake.

[7] This tuition fee exemption was later extended for two more academic years.

On the one hand, significant disruptions in the learning environment and the fear that the earthquake could strike again in the near future could have discouraged a lot of potential students from enrolling at the University of L'Aquila. Several US reports (see, for instance, Noel-Levitz Inc. 2012) show that campus appearance is among the most important factors affecting students' decision about where to study. Other papers (see, for instance, Absher and Crawford 1996; Dubey 2013) report that educational infrastructure and facilities play an important role in influencing students' enrolment choices. In Italy, the results of a survey of 1,500 upper secondary school students are in line with the above findings. Organizational aspects of an institution and the general atmosphere in the area where this institution is located are ranked as the fourth most important factor that respondents will consider when deciding about which university to attend[8].

On the other hand, the tuition fee exemption policy adopted by the University of L'Aquila in the aftermath of the natural disaster could have enhanced the relative attractiveness of this institution, given that all the other Italian universities continued to charge tuition fees. Several papers conclude that tuition fees influence a student's decision about which institution to attend. Hilmer (1998) finds that post-secondary fees are an important factor in determining a student's choice of whether to start his or her college education at a university or a community college. Long (2004) shows that potential students pay attention to tuition price when they decide which college they want to go to.

There is an additional channel through which the L'Aquila earthquake could have impacted university enrolment. Following this natural disaster the local unemployment rate has increased and lower employment opportunities could have induced many high school leavers

[8] Uno studente su due è influenzato dai genitori nella scelta dell'università, La Stampa, 16/7/2013, Retrieved February 2, 2015, from http://www.lastampa.it/2013/07/16/cultura/scuola/uno-studente-su-due-influenzato-dai-genitori-nella-scelta-delluniversit-cH3fCGfS6gVYGLRYpGi8bO/pagina.html

from L'Aquila to study at the local university. The earthquake has significantly reduced their opportunity cost of university education. Several studies (see, for instance, Di Pietro 2004) show that in Italy declining local labour market conditions (proxied by regional unemployment rate) lead to an increase in the probability that a high school graduate enrols at university.

Another paper examines the effects of the L'Aquila earthquake on the local university. However, in contrast to the present study that analyses how this event has affected prospective students' enrolment decisions, Di Pietro (2015) looks at how the L'Aquila earthquake has impacted the subsequent educational performance of current students. He finds that while the natural disaster has reduced students' probability of graduating on time by 6.6 percentage points, it has had no statistically significant effect on drop-out. It is argued that these findings could be driven by post-disaster interventions (e.g. tuition fee exemption) as well as by expected unfavourable labour market conditions after the earthquake.

3. Empirical strategy and data

3.1 Empirical strategy

We employ the synthetic control method to construct a counterfactual post-earthquake first-year enrolment path for the University of L'Aquila. This method builds on difference-in-differences estimation, but uses arguably more attractive comparisons to get causal effects (Athey and Imbens 2016). It has three main advantages. First, the counterfactual is a weighted average of Italian universities, whose size and structure are similar to those of the University of L'Aquila, that have not been exposed to the earthquake. This is important as neither the set of all Italian universities nor a single Italian university is likely to approximate

the most relevant characteristics of the University of L'Aquila. Additionally, this data-driven procedure reduces the discretion in the decision about what to include in the control/comparison group. Second, as the choice of the synthetic control does not require access to post-earthquake data, this selection is made without knowing its impact on enrolment. Third, unlike several other techniques[9], the synthetic control method allows the effects of unobservable confounders to vary with time.

Specifically, let the index $j = (0,1,..., J)$ denotes Italian universities. While $j = 0$ indicates the University of L'Aquila, $j = (1,..., J)$ refer to each of the other J universities that can be potentially included in the control group. Define X_0 as a $(k \times 1)$ vector with elements equal to the first-year enrolment at the University of L'Aquila in each academic year during the pre-earthquake period plus additional covariates predictive of first-year enrolment. Similarly, define X_1 as the $(k \times J)$ vector containing the same variables for each of the J universities in the control group[10].

The synthetic control approach identifies a convex combination of the J universities in the control group that best approximates the pre-earthquake data vector for the University of L'Aquila. Define the $(J \times 1)$ weight vector $W = (w_1, w_2, ..., w_J)$ such that all weights are non-negative and sum to one; that is $w_j \geq 0$ for $j = (1,..., J)$ and $\sum_{j=1}^{J} w_j = 1$. The product $X_1 W$ then gives us a weighted average of the pre-earthquake vectors for all universities omitting the University of L'Aquila, with the difference between the University of L'Aquila and this

[9] For instance, the fixed effect estimation strategy enables us to account for just time-invariant confounding factors, while the difference-in-differences approach permits these factors only to share a common trend (Billmeier and Nannicini 2013).

[10] See Section 3.2 for the list of variables included in X_0 and X_1.

average given by $(X_0 - X_1 W)$. The synthetic control method chooses a value for W such that

$$W^* = \arg\min_W (X_0 - X_1 W)' V (X_0 - X_1 W) \quad (1)$$

where V is a $(k \times k)$ diagonal positive-definitive vector with diagonal elements providing the relative weights for the contribution of the square of the elements in the vector $(X_0 - X_1 W)$ to the objective function being minimised.

Once W^* is selected, it is possible to tabulate both the pre-earthquake path and the post-earthquake values for first-year enrolment in the synthetic control unit by calculating the corresponding weighted average for each academic year using the universities with positive weights. Therefore, one can assess the earthquake's impact by simply comparing this counterfactual to the actual path observed.

3.2 Data

Our outcome variable is university-level undergraduate first-year enrolment between the academic years 2000/01 and 2011/12[11]. Given that the earthquake took place in April 2009, the pre-disaster period comprises 9 academic years, while 3 academic years make up the post-disaster period. Enrolment data are from the Italian Ministry of Education, Universities and Research (MIUR)[12].

[11] Unfortunately data for earlier and later academic years are not comparable with those included in the analysis given a change in the methodology used to compute first-year university enrolment.
[12] One should note that during all the academic years considered in this paper there have been no changes in the general rules governing the access to university education. In Italy all high school graduates gain the automatic

In addition to past realizations of the outcome, several variables are employed as predictors of first-year university enrolment in order to construct the synthetic control. First, we use youth unemployment rate (between the ages of 15-29) in the province where the university is located in an attempt to measure the opportunity cost of university education. Data are from the Italian National Statistical Institute (ISTAT) and the period covered goes from 2004 to 2008. The rationale for this variable is that, as discussed in Section 2, poor local employment opportunities may induce high school leavers to enrol at university. We also include GDP per capita in the province where the university is located. Again, data are from ISTAT and cover the period 2004 to 2008[13]. This is a proxy for local income levels that could reflect the ability to pay for university education. There is a lot of research at micro-level showing that parental income affects children's chances of attending university. Anders (2012) looks at the relationship between household permanent income and university attendance for a cohort of English students. He concludes that those in the top fifth of the income distribution are about 2.7 times more likely to go to university than those in the bottom fifth.

On the other hand, average tuition fees paid by undergraduate students are employed as a measure for the cost of university education. Data on this variable are available for 4 academic years prior to the earthquake, come from the MIUR, and are broken down by university. There are a lot of studies, mainly from the US (see, for instance, Heller 1997; Helmet and Marcotte 2008) and Europe (see, for instance, Dolton and Lin 2011 for the UK and Hübner 2012 for Germany), that highlight the effect of tuition fees on university enrolment. Even though in Italy tuition fees are rather modest in comparison with the US and

right to enrol in university studies, provided that they have successfully completed five years in high school. There are no admission standards, except for courses with limited places.

[13] Data for earlier years are unavailable because of a change in the methodology used to compute both unemployment rate and GDP.

the UK, there is evidence that they have a considerable bearing on higher education choices (Staffolani and Pigini 2012).

Furthermore, we consider the quality of higher education institutions as an additional factor influencing students' enrolment decisions. Evidence, especially from the US and the UK, suggests that prospective students use university rankings, which are based on different measures of institutional quality, to decide which university they want to apply to. For instance, in a seminal paper Monks and Ehrenberg (1999) show that US News and World Report (USNWR) college rankings affects admission at selective private institutions. The UK study by Broecke (2015) finds that an improvement in the rankings leads to an increase in the number of applications received. In this paper, we employ two indicators, which are available at faculty level, to measure the quality of Italian universities. The first measure comes from a research evaluation survey carried out in 2006 by the Supervising Committees for Research Evaluation (CIVR) jointly with MIUR. This indicator reflects the average score received by a faculty across a range of learning and research-related areas[14]. Our second quality measure is from performance-based league tables of Italian universities published in 2009[15] by *La Repubblica* newspaper and it is based on the analysis carried out by the Centre for Social Studies (CENSIS). This measure represents the average score obtained by a faculty in the following four areas: 1) teaching, 2) research outcomes, 3) student progression and achievement, and 4) internationalization[16].

Finally, we also use two variables related to the composition of the first-year student population: proportion of males and proportion of individuals aged 20 or below.

[14] A score between 0 and 1 is awarded.
[15] These measures refer to the academic year 2007/08.
[16] In each of these areas a score between 0 and 110 is awarded.

In selecting a synthetic control that includes Italian higher education institutions "comparable" to the University of L'Aquila, the original donor pool is reduced according to the following three criteria. First, since the University of L'Aquila is a medium-sized university we eliminate large and small-sized universities (i.e. with more than 5,150 or less than 900 first-year students in the academic year during which the earthquake occurred). Second, we also remove universities founded after 2001 and those offering only virtual education programs. Third, we include in the donor pool only institutions that have at least 3 of the following 6 Faculties of the University of L'Aquila: Economics[17], Engineering, Arts and Philosophy, Medicine and Surgery, Education[18], and Mathematical, Physical and Natural Sciences). In fact, out of the 9 Faculties of the University of L'Aquila (see Section 2) 3 have been excluded from our analysis. While Biotechnology and Psychology are omitted because they were established at the University of L'Aquila in 2005, Sport Sciences is eliminated given that the number of universities with this Faculty and the corresponding number of enrolled students are both very small. Our final donor pool comprises 25 universities.

Table 1 reports the summary statistics for all the variables used in the analysis.

Insert Table 1 about here

[17] However, within the Faculty of Economics first-year enrolment in the degree program for "legal-economic analysis" has been adjusted to control for the huge unusual growth experienced by this degree program in the academic year 2010/11. An agreement between the University of L'Aquila and the Italian Finance Police ("Guardia di Finanza") has driven this enrolment growth. A simple linear extrapolation was used to predict the first-year enrolment that this degree program would have experienced in the academic year 2010/11 had the above agreement not been in effect.

[18] However, within the Faculty of Education first-year students enrolled in the "investigation sciences" degree program are excluded from our analysis. Not only did this degree program end in 2011, but for some years the University of L'Aquila has been the only Italian higher education institution offering it.

4. Results

The synthetic control method[19] delivers positive weights for University of Sannio (0.107), University of Parma (0.159), University of Basilicata (0.436) and Ca' Foscari University of Venice (0.298)[20] (see Fig. 1 for the geographical localization of these institutions).

Insert Fig. 1 about here

Table 2 reports the average characteristics of the University of L'Aquila (Column 1), its synthetic control (Column 2) and all the universities in the final donor set (Column 3) during the pre-earthquake period. The synthetic control resembles the University of L'Aquila more closely than the entire donor pool in all the variables considered apart from the CIVR score.

Insert Table 2 about here

Not only, as indicated in Table 2, is average first-year enrolment at the University of L'Aquila close to that of the synthetic control before the earthquake, but also, as depicted in Fig. 2, during the pre-earthquake period both the treated and synthetic units show a similar first-year enrolment trend. Two exceptions occur in the academic years 2003/04 and 2008/09, where first-year enrolment at the University of L'Aquila exceeds that of the synthetic unit by 10.1 and 6.6 percentage points, respectively. However, these outliers are an artefact of the data and are not driven by underlying policy changes implemented by the University of L'Aquila that would affect first-year enrolment. The average pre-disaster first-year enrolment

[19] In the estimation, we employ the *synth, nested* STATA command that has been developed by Abadie, Diamond and Hainmueller.

[20] One may note that none of the universities included in the synthetic control is geographically close to L'Aquila (the closest institution is the University of Sannio, which is located 147 miles away from L'Aquila). This consideration is important as students who would have attended the University of L'Aquila had the earthquake not occurred could have enrolled at institutions located in an area near L'Aquila (in Italy many university students continue to live at home with their parents). Therefore, our estimates are unlikely to be biased as a result of this spillover effect.

difference between the University of L'Aquila and the synthetic control is very small (i.e., -3.79 first-year students), with a root mean square prediction error of 153.03.

Fig. 2 shows that the earthquake has an immediate negative effect on first-year enrolment, as there is a sharp drop in first-year enrolment at the University of L'Aquila relative to the synthetic control in the academic year 2009/10. But interestingly, such a negative impact is very short-lived as it is followed by a recovery that in the academic year 2011/12 even surpasses the counterfactual estimate. More precisely, our analysis indicates that while in the academic year 2009/10 first-year enrolment at the University of L'Aquila was 15.8% lower than in the synthetic unit, this gap was completely reduced in the next academic year. Then, in the academic year 2011/12 first-year enrolment at the University of L'Aquila was 10.3% higher than in the counterfactual scenario in which the earthquake did not occur.

Insert Fig. 2 about here

In order to test the significance of the observed relative change in first-year enrolment experienced by the University of L'Aquila following the earthquake, we perform a placebo test. This test, which was first proposed by Abadie et al. (2010), is now commonly used in papers employing a synthetic control approach (see, for instance, Ando 2015; Grier and Maynard 2016; Pinotti 2015). It consists in virtually reassigning the treatment to higher education institutions unaffected by the earthquake and included in the final donor pool. Therefore, it is assumed that each unaffected university had experienced the earthquake at the same time as the University of L'Aquila. Placebo effects are computed by comparing the divergence of actual first-year enrolment from its synthetic control for the University of L'Aquila with that for the other universities included in the final donor pool. The distribution of these placebo effects would give us an idea about whether the relative change in first-year

enrolment experienced by the University of L'Aquila after the disaster is different relative to those experienced by other higher education institutions.

Fig. 3 depicts the result of the placebo test. The placebo effects for each of the donor higher education institutions are displayed with thin grey lines, while the corresponding effect for the University of L'Aquila is displayed with the thick black line. This figure shows that during the post-disaster period the first-year enrolment gap associated with the University of L'Aquila lies within the distribution of the placebo effects, suggesting that the University of L'Aquila does not stand out as an outlier during this period. Even in the academic year just after the earthquake the negative gap in the number of first-year students for the University of L'Aquila is not statistically significant as it is larger than most, but not all, the placebo gaps[21]. Following Ando (2015) and Grier and Maynard (2016), we conduct four additional placebo/robustness tests. Appendix A describes them and reports the results. All these checks confirm the robustness of the findings shown in Fig. 3.

Insert Fig. 3 about here

Fig. 4 shows the impact of the earthquake on first-year enrolment separately for each of the 6 Faculties of the University of L'Aquila. In line with Fig. 2, Fig. 4 depicts the fit in the pre-earthquake period and a comparison post-earthquake of the actual values and the synthetic controls. Fig. 4 reveals that the effect of the L'Aquila earthquake on first-year enrolment varies significantly across Faculties. While in the post-earthquake period first-year enrolment at the Faculties of Economics and Arts and Philosophy diverges upward from its synthetic counterpart, the opposite holds for first-year enrolment at the Faculties of Engineering and

[21] As a robustness test we use a difference-in-differences estimation strategy to estimate the impact of the earthquake on first-year enrolment at the University of L'Aquila in the academic year immediately after the earthquake. We regress the difference in the number of first-year students at the University of L'Aquila and its counterfactual in that academic year against the same covariates used in the synthetic control method and a treatment dummy. Although the coefficient on the treatment dummy has a negative sign as expected, its corresponding p-value is slightly above the 10% level of statistical significance.

Medicine and Surgery. This gap appears to be especially wide for the Faculties of Economics and Engineering. Although the L'Aquila earthquake had short-term negative consequences on first-year enrolment at the Faculties of Education and Mathematical, Physical and Natural Sciences, in both cases this was followed by a rebound increase.

Insert Fig. 4 about here

In Fig. 5 the results of the placebo tests are shown. They confirm that a negative effect on first-year enrolment caused by the earthquake appears to be particularly plausible for the Faculty of Engineering as the gap in the number of first-year students becomes clearly larger than all the placebo gaps in the post-disaster period. The validity of the estimated negative effect on first-year enrolment at the Faculty of Medicine and Surgery is weaker as the treatment effect is larger than most (but not all) placebo effects. A similar consideration can be made by looking at the result of the placebo test about the increase in first-year enrolment at the Faculty of Economics following the earthquake. Fig. 5 shows that there are few placebo effects that are larger than the treatment effect.

Insert Fig. 5 about here

Next, we look at whether the effect of the earthquake on first-year enrolment at the University of L'Aquila varies across gender and age groups.

The top panels of Fig. 6 suggest that the effect of the earthquake on first-year enrolment differs by gender, with women being more negatively affected than men. However, placebo testing results, which are depicted in the bottom panels of Fig. 6, indicate that the earthquake caused a statistically relevant reduction in first-year female enrolment only in the academic year immediately after the disaster. Between the academic years 2010/11 and 2011/12, though first-year female enrolment at the University of L'Aquila is lower than the estimated

counterfactual, the placebo test for this variable is not particularly robust. As regards first-year male enrolment, during the whole post-earthquake period the University of L'Aquila data points clearly lie within the distribution of placebo estimates, indicating that the University of L'Aquila is not an outlier in this period.

Insert Fig. 6 about here

One reason why the earthquake has diverted female students from enrolling at the University of L'Aquila may lie in gender differences in the perception of risk of earthquakes. Kung and Chen (2012), using data from Taiwan on both earthquake survivors and individuals in the general population who have not been exposed to earthquakes, find that women are significantly more likely to worry about the reoccurrence of an earthquake relative to men. This result is in line with that obtained by Cameron and Shah (2015). They discover that, among a population of individuals from rural Indonesia who recently suffered a flood or earthquake, women are more likely to perceive that they now face a greater risk of a future disaster. Given that L'Aquila was not hit again by an earthquake after 2009, it is possible that the magnitude of this effect has lessened over time and this could have contributed to drive the rebound in first-year female enrolment observed since the academic year 2010/11.

Synthetic control results for first-year enrolment among students aged 20 or below and those aged 21 or above are shown in Fig. 7. The top right panel of this figure clearly indicates that after the earthquake there has been a substantial increase in the number of first-year students aged 21 or over. The placebo test reported in the bottom right panel of Fig. 7 confirms the robustness of this effect. When it comes to first-year enrolment among students aged 20 or under, our findings indicate a statistically relevant reduction only during the academic year 2009/10.

Insert Fig. 7 about here

Finally, Fig. 8 shows the synthetic control results by age and gender. They indicate that the post-earthquake period has been characterised by a surge in the enrolment of older first-year students across both males and females. This increase played a crucial role especially in the academic year just after the earthquake. It prevented an ever greater decline in overall first-year enrolment which was caused by a significant reduction in the number of first-year students aged 20 or below. In the two successive academic years both the rebound in first-year enrolment of younger students and the high first-year enrolment level of older students contributed to the upward trend shown in Fig. 2.

Insert Fig. 8 about here

The increase in first-year enrolment of older male and female students following the L'Aquila earthquake may underscore the importance of the post-disaster measures discussed in Section 2. These measures, which were designed to make the university more attractive to prospective students despite the damages caused by the earthquake, could have been especially appealing to people aged 21 or above. The tuition fee exemption could have encouraged particularly the enrolment of those older people who, before the earthquake, were unable to afford the cost of university education in light of their economic and family commitments. It might have also increased participation in higher education of those older individuals with no particularly strong financial constraints but facing a high marginal cost of enrolment (e.g. working individuals with lifelong ambitions linked to a specific degree program). Similarly, an effective VLE, adopted by the University of L'Aquila following the earthquake, could have favoured the enrolment of a lot of older students. A VLE may help them to fit their university studies around their busy work and family life. They can study at their own pace and have access to teaching resources they need in the format that suits them

best (Newson et al. 2011). Finally, it is worth to mention that in Italy most public sector working people without a university degree have great incentives to get one as this may significantly increase their chances of being promoted. This consideration is relevant in this context as the number of public sector employees in L'Aquila is very large given that, as the capital of Abruzzo region, this city hosts regional governments' offices in addition to provincial and municipal ones[22].

5. Conclusions

This paper adds to the growing literature on the socio-economic effects of natural disasters by investigating how an earthquake may affect future university enrolment. Not only is this a relevant educational issue, but it may have wider implications if before the earthquake the university was a major contributor of the local economy. The potential decline in the university enrolment following the disaster could have considerable detrimental economic effects given the important role of students in providing jobs, rental income and demand for local goods and services.

With the above in mind, we have examined the impact of the L'Aquila earthquake on first-year university enrolment at the local university. Using a synthetic control method, we have found that this event has had no statistically significant effect on the number of students enrolled at the University of L'Aquila in the three academic years after the earthquake. This result is not at variance with those of previous studies showing that natural disasters do not have any economic effect in the short term. For instance, Loayza et al. (2012), applying a dynamic generalised method of moments panel estimator to a 1961–2005 cross-country panel dataset, conclude that earthquakes do not affect economic growth over a five-year period.

[22] As stated in a report carried out by the Ministry for Territorial Cohesion (2012), public sector is by far the most important source of employment for the city of L'Aquila.

Our result is also in line with the fact that the labour market outcomes of recent graduates from the University of L'Aquila are found to be quite good in the post-earthquake period. Data from Almalaurea[23] show that in 2015 66% of these graduates were in employment one year after graduation. This figure increases to 80% and 87% when looking at two and three years after graduation, respectively. Additionally, graduates from the University of L'Aquila are satisfied with the education received notwithstanding the disruptions caused by the natural disaster. 71% of them indicate that they would choose the same university if they could make this choice again. This underscores the great efforts made by the University of L'Aquila to keep academic standards up and to prepare the students for the labour market despite all the problems caused by the earthquake.

Although our estimates indicate that the L'Aquila earthquake did not significantly affect first-year enrolment at the local university in the short-term, this aggregate result masks some important differences. While the natural disaster negatively impacted the enrolment of younger people (i.e. aged 20 or below), this decline was offset by an increase in the number of older students (i.e. aged 21 or above). What has driven the surge in the enrolment of older students? Although we are unable to empirically test for this, our results are consistent with the explanation that highlights the importance of post-disaster measures adopted in an attempt to counter the likely negative effects on enrolment triggered by the earthquake. We expected measures such as the tuition fee exemption and the creation of a VLE to favour especially the enrolment of mature students. These provisions have eliminated the financial constraints often faced by older students and have provided them with an online learning support platform that is an essential tool for those who wish to study in flexible ways.

[23] Lavorare dopo la laurea L'Aquila guida la classifica 08/06/2015. Retrieved June 27, 2016, from http://ilcentro.gelocal.it/laquila/cronaca/2016/06/08/news/lavorare-dopo-la-laurea-l-aquila-guida-la-classifica-1.13628974

Our empirical results indicate also that the effect of the L'Aquila earthquake on first-year enrolment differs by Faculty. In particular, this event has led to a statistically significant decline in first-year enrolment at the Faculty of Engineering. Although the reasons for this result are not determined in this work, it is possible that an important cause lies in the particularly severe and prolonged disruption experienced by the students of this Faculty following the disaster. The buildings of the Faculty of Engineering were especially hit hard by the earthquake and, despite the fact that temporary arrangements were made to help students continue studying, the quality of student life inevitably worsened as a result of this.

Finally, important lessons can be learnt from governmental and other organizational responses to the L'Aquila earthquake. Although lesson drawing is a difficult exercise, it is possible to identify four measures that may assist policy-makers in attempting to counteract a possible decline in enrolment faced by educational institutions hit by natural disasters.

1) Following the destruction of educational infrastructure caused by the natural disaster, it is important that the affected educational institutions are able to quickly transfer their functions, including classes, dormitories, and canteens, to new locations. Not only should continuity in education be insured, but teachers and students need a learning environment characterised by security and safety. This would send a clear signal to current and prospective students that these institutions continue to be strongly committed to providing education.

2) Reducing both the direct and indirect costs of education may encourage existing students to stay on after the natural disaster and also offer an incentive to new students to enrol. A tuition fee exemption may be a particularly good measure in this context. Although in this paper we are unable to disentangle the effect of this provision, more recent data seem to suggest that it has played a key role in rising enrolment at the University of L'Aquila after the natural disaster. In the academic year 2014/15, following the end of the tuition fee exemption

period, first-year enrolment at the University of L'Aquila dropped considerably relative to both earlier post-earthquake years and enrolment at many other universities located in the Centre and South of Italy[24].

3) In order to offset the substantial disruptions in student learning caused by the natural disaster, educational institutions should implement a VLE or make the current one more effective. This allows students to access relevant learning material and keep in touch with teachers and peers without the need to physically meet them.

4) Barriers to access to specific educational courses should be, at least temporarily, removed following the natural disaster. For instance, in Italy some university courses have limited places. Selection into these courses is competitive and is typically based on an academic test. In order to boost student numbers, in the post-disaster period an open admission policy should be established for any course so that students are free to enrol on their preferred one. Following the earthquake, the University of L'Aquila might have been able to sustain enrolment also by delaying the process whereby some of the existing courses have limited places. Some courses started to have limited places only five years after the earthquake[25].

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Conflict of Interest: The authors declare that they have no conflict of interest.

[24] Univaq, crollo di iscritti e immatricolati. Inverardi: "Scenario previsto" 03/06/2015. Retrieved June 15, 2016, from http://news-town.it/studentown/8056-per-l-anagrafe-nazionale-studenti-crollo-di-immatricolati-e-iscritti-all-univaq-i-dati-elaborati-dall-udu.html

[25] Calo immatricolazioni L'Aquila: la voce degli studenti 04/06/2015. Retrieved June 16, 2016, from http://www.improntalaquila.org/2015/calo-immatricolazioni-laquila-la-voce-degli-studenti-video-83873.html

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Appendix A - Additional placebo/robustness tests

A.1. Comparison between average estimated effects

We carry out another placebo test in which we compute the average estimated effect of the earthquake on first-year enrolment at the University of L'Aquila and at the control universities (i.e. placebo effects) in the three post-disaster academic years. Then the size of the divergence in the actual average number of first-year students at the University of L'Aquila from its synthetic control is tested by the distribution of average placebo effects for all the control universities. Fig. 9 shows that the average estimated post-earthquake effect at the University of L'Aquila lies within the distribution of the placebo effects, and hence there is no evidence of a statistically significant effect.

Insert Fig. 9 about here

A.2. Distribution of the ratios of post/pre earthquake MSPE

Using the difference between the actual number of first-year students and the synthetic control at the University of L'Aquila and at control universities, which were obtained from the first placebo exercise (see Fig. 3), we look at the distribution of the ratios of post/pre-earthquake mean square prediction error (MSPE). Fig. 10 displays the distribution of the post/pre-earthquake ratios of the MSPE for the University of L'Aquila and all 25 control universities. The post-earthquake MSPE for the University of L'Aquila University is about 3 times higher than the corresponding one in the pre-earthquake period. However, as several control universities have larger ratios, this test confirms that the treatment effect for the University of L'Aquila is not statistically significant.

Insert Fig.10 about here

A.3. In-time placebo

Additionally, we run two in-time placebo tests, in which the earthquake year is artificially changed keeping fixed the final donor pool and the treated university. The fake treatment years are: 2005 and 2007. Figure 11 shows that the divergence between actual and synthetic first-year enrolment at the University of L'Aquila is not significant for any of the two fake treatment years. This indicates that the lack of any significant effect obtained in Fig.2 is not driven by chance.

Insert Fig.11 about here

A.4. Jackknife

Finally, we run the Jackknife on the baseline model dropping each university receiving a non-trivial weight one at a time. So we consider versions of the model which exclude, in order, University of Sannio, University of Parma, University of Basilicata and Ca' Foscari University of Venice. The results for these versions of the model are presented in Fig. 12. The exclusion of these universities has no meaningful effect on our results.

Insert Fig.12 about here

Table 1: Descriptive statistics

	Period of reference	All donors		The University of L'Aquila	
		Mean	s.d.	Mean	s.d.
Number of first-year students	Between academic years 2000/01 and 2008/09	3335.62	1457.20	2418.89	267.40
Proportion of first-year students aged 20 or below	Between academic years 2000/01 and 2008/09	0.757	0.086	0.821	0.026
Proportion of male first-year students	Between academic years 2000/01 and 2008/09	0.443	0.059	0.461	0.017
Unemployment rate in the province where the university is located	Between 2004 and 2008	15.11	9.33	19.77	2.46
GDP per capita (current prices in euro) in the province where the university is located	Between 2004 and 2008	24105.60	5502.38	19120.00	1603.75
Average tuition fees (current prices in euro)	Between academic years 2005/06 and 2008/09	790.82	299.71	668.95	102.81
Average CIVR score	In 2006	0.787	0.068	0.805	N/A
Average CENSIS score	In the academic year 2007/08	87.79	5.11	79.92	N/A

Table 2: Balancing properties (pre-earthquake period)

	Period of reference	The University of L'Aquila (1)	Synthetic control (2)	All donors (3)
Average number of first-year students	Between academic years 2000/01 and 2004/05	2494.80	2457.79	3408.49
Average number of first-year students	Between academic years 2005/06 and 2007/08	2211.00	2340.32	3260.76
Number of first-year students	In the academic year 2008/09	2663.00	2494.22	3048.08
Average proportion of first-year students aged 20 or below	Between academic years 2000/01 and 2008/09	0.82	0.78	0.76
Average proportion of male first-year students	Between academic years 2000/01 and 2008/09	0.46	0.46	0.44
Average unemployment rate in the province where the university is located	Between 2004 and 2008	19.77	18.60	15.11
Average GDP per capita (current prices in euro) in the province where the university is located	Between 2004 and 2008	19120.00	22458.36	24105.60
Average tuition fees (current prices in euro)	Between academic years 2005/06 and 2008/09	668.95	669.22	790.82
Average CIVR score	In 2006	0.81	0.85	0.79
Average CENSIS score	In the academic year 2007/08	79.92	85.28	87.79

Fig. 1 Geographical localization of the University of L'Aquila and the other Italian universities

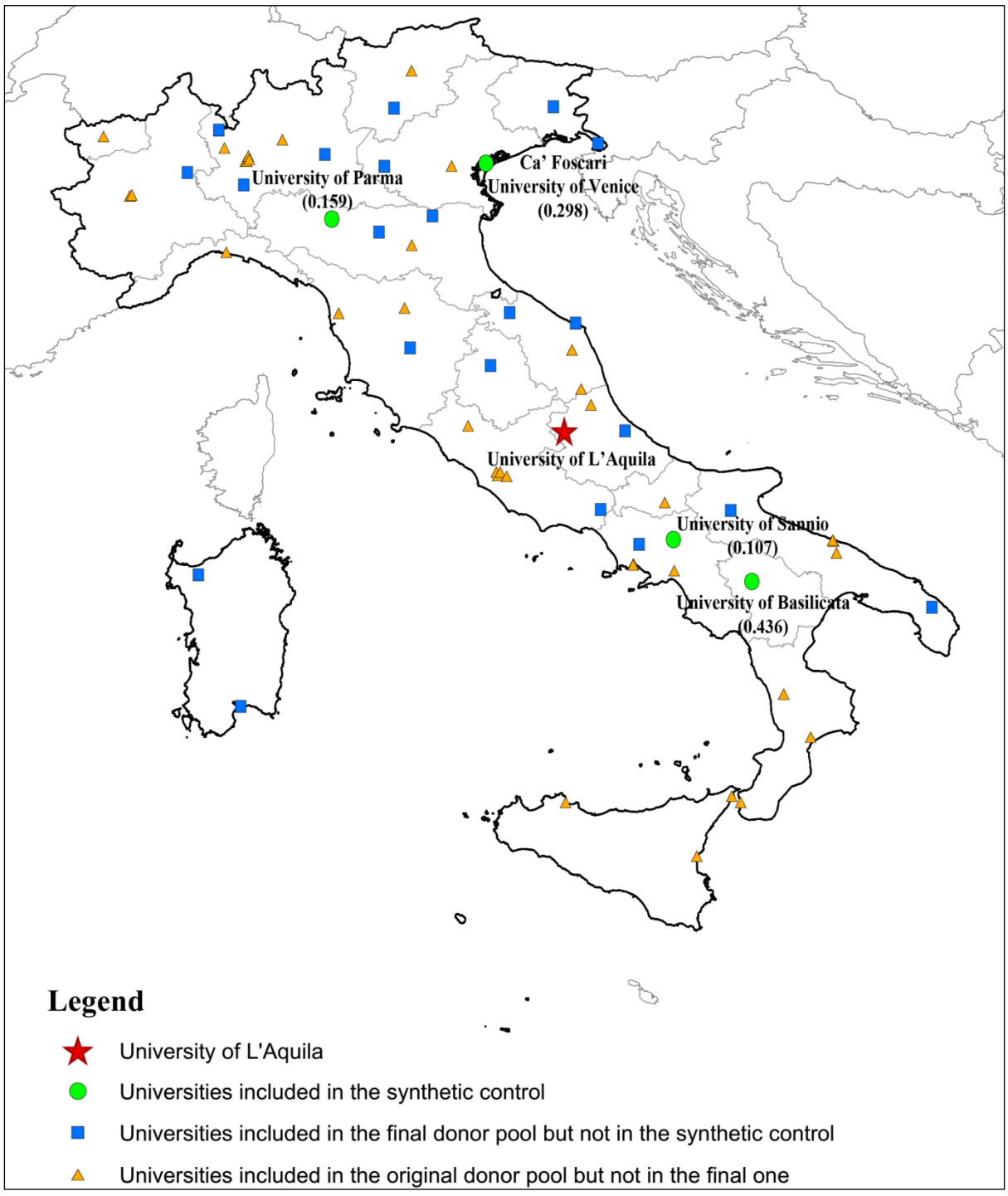


Fig. 2 Number of first-year students at the University of L'Aquila and at the synthetic comparison group, academic years 2000/01-2011/12

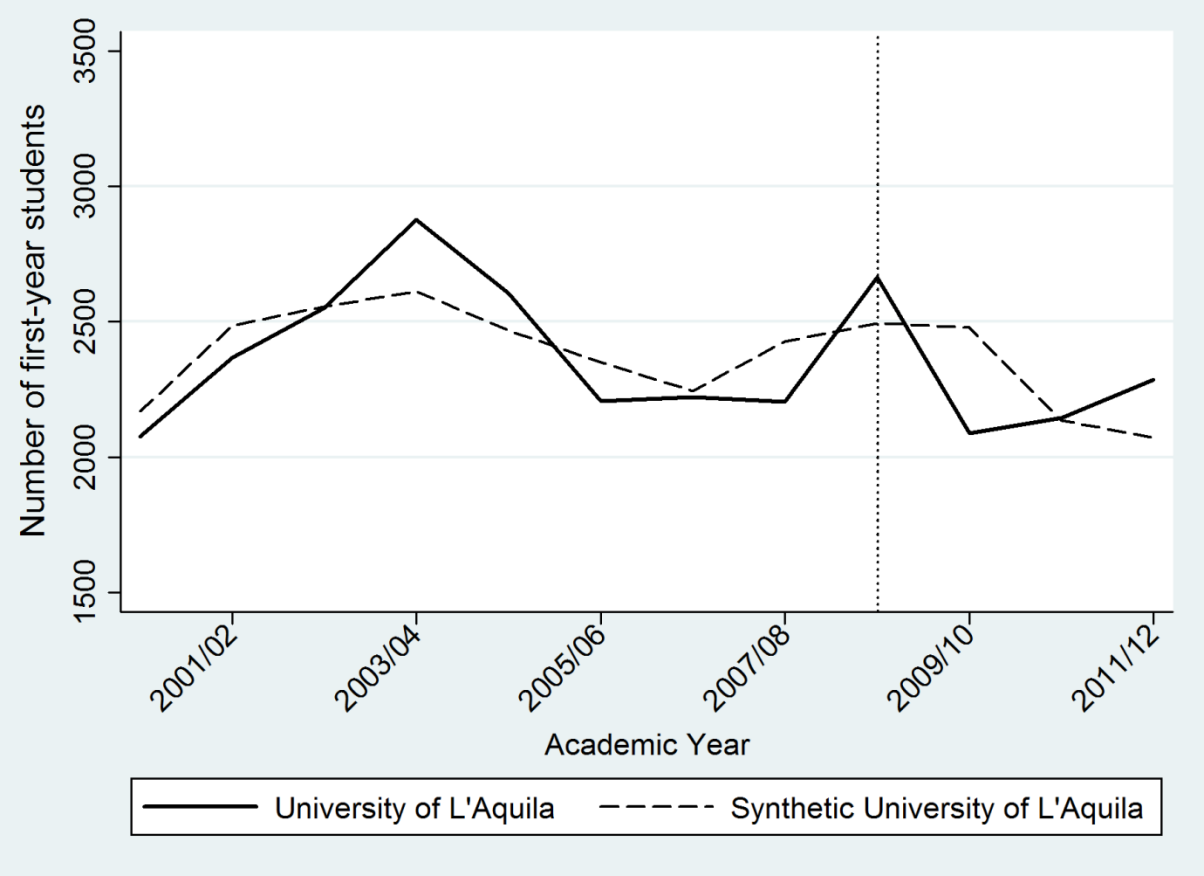


Fig. 3 Number of first-year students' gap at the University of L'Aquila and placebo gaps at control universities, academic years 2000/01-2011/12

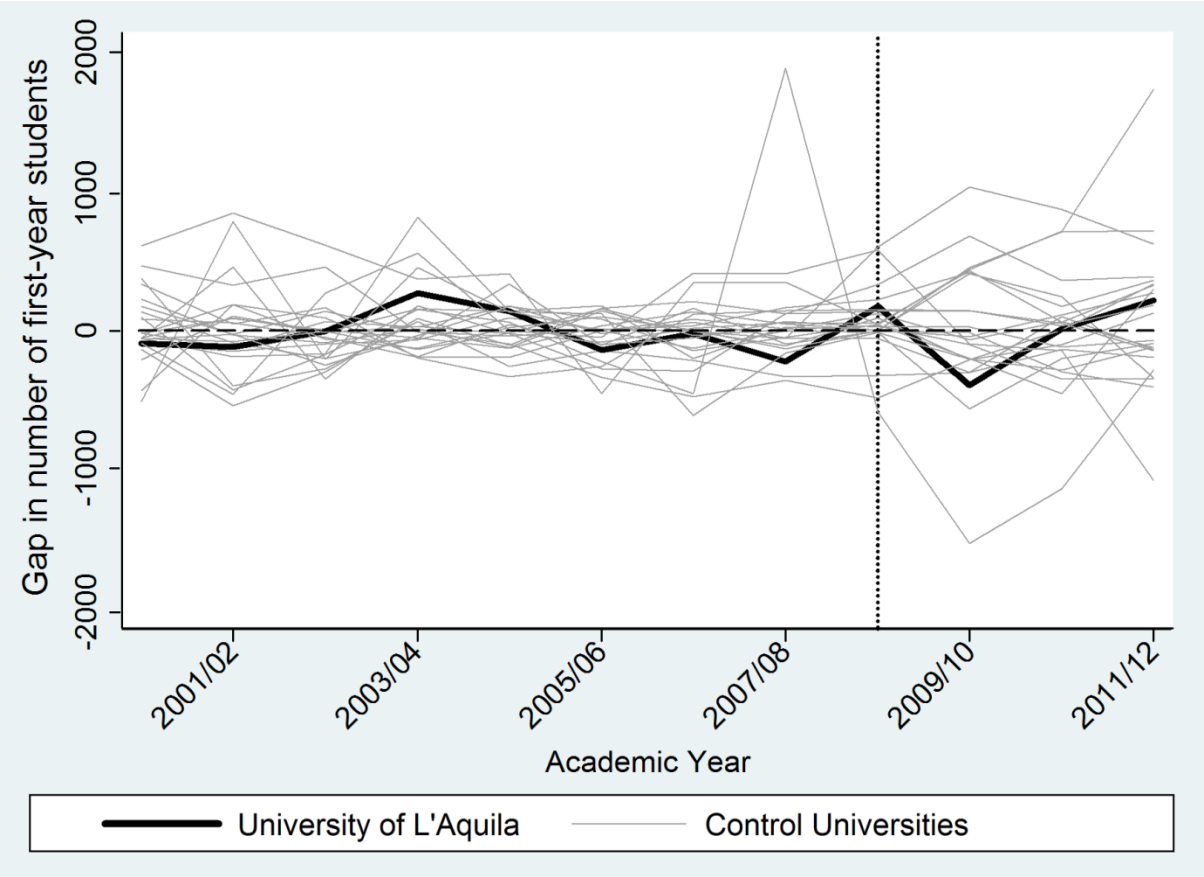


Fig. 4 Number of first-year students by Faculty at the University of L'Aquila and at the synthetic comparison group, academic years 2000/01-2011/12

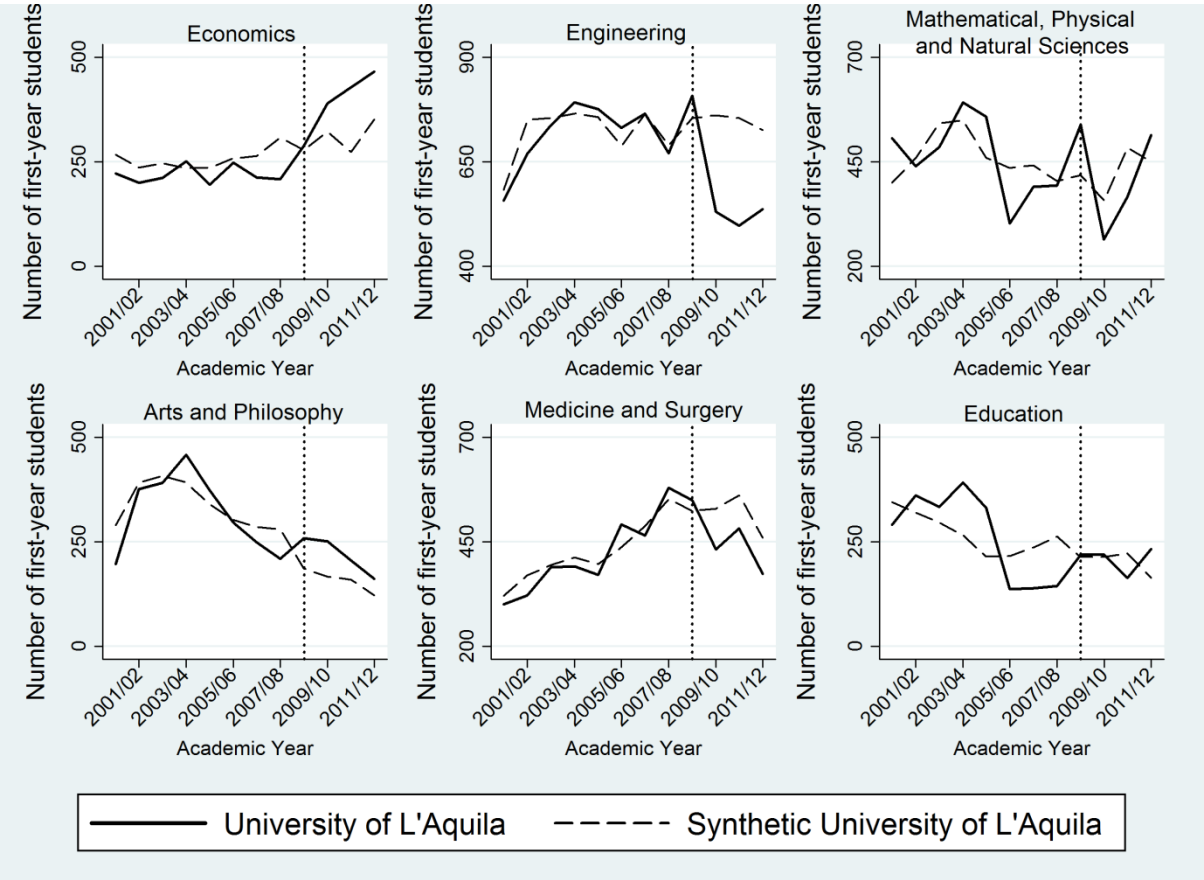


Fig. 5 Number of first-year students' gap by Faculty at the University of L'Aquila and placebo gaps by Faculty at control universities, academic years 2000/01-2011/12

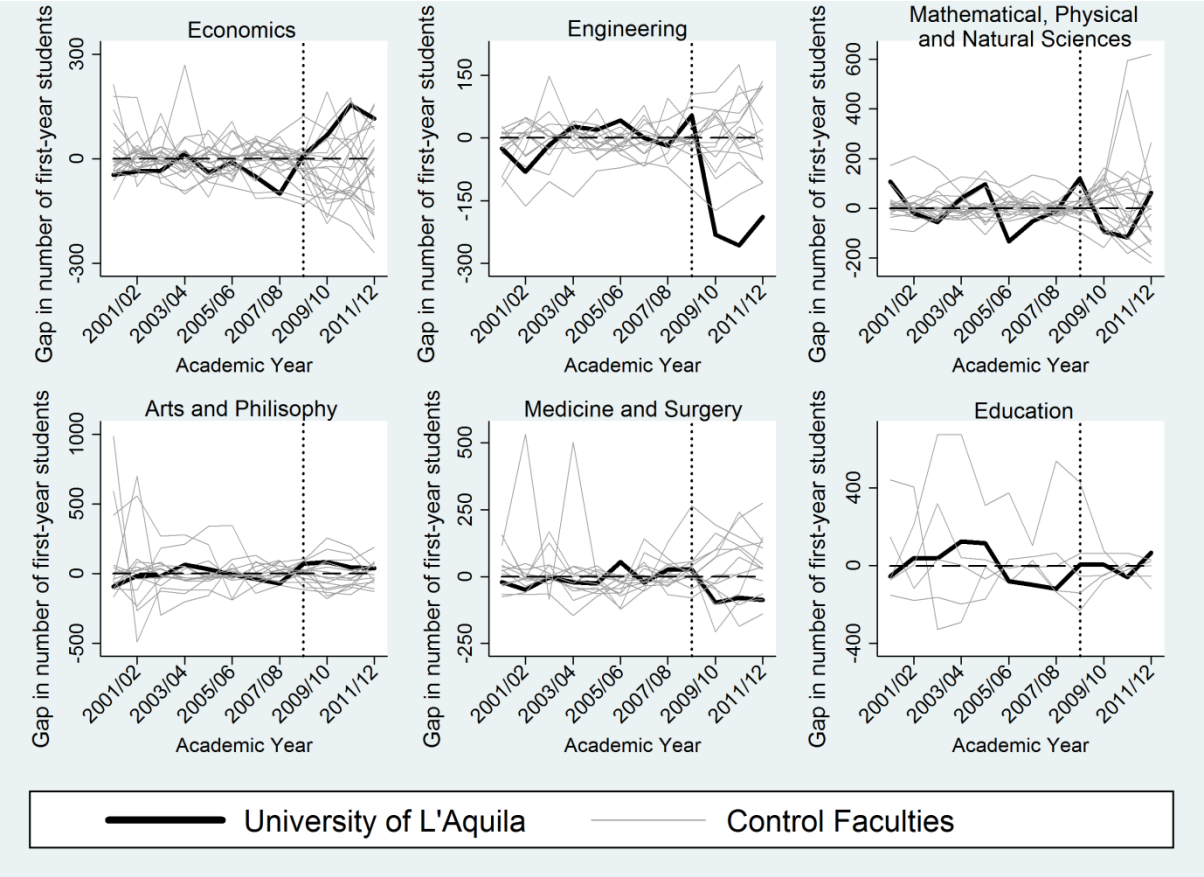
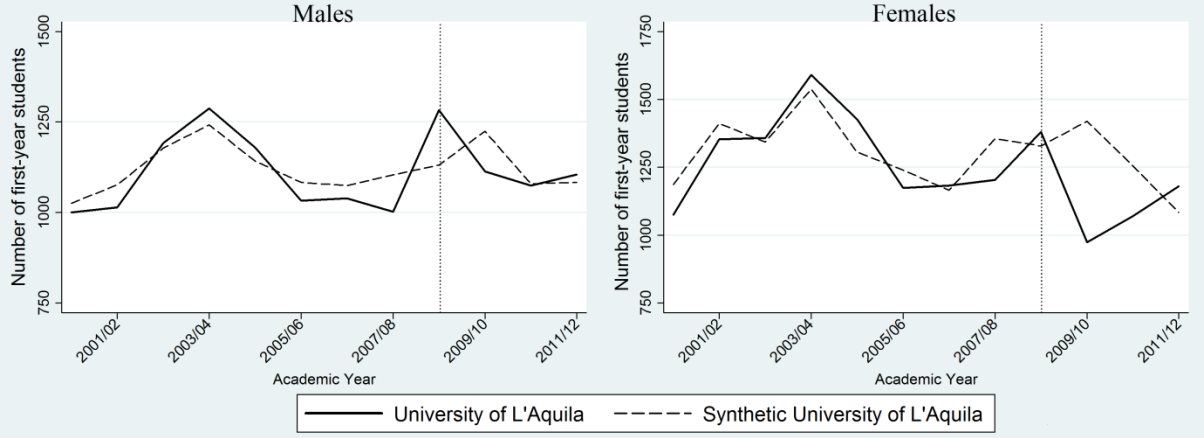


Fig. 6 Synthetic control results by gender, academic years 2000/01-2011/12

Number of first-year students by gender at the University of L'Aquila and at the synthetic comparison group



Number of first-year students' gap by gender at the University of L'Aquila and placebo gaps by gender at control universities

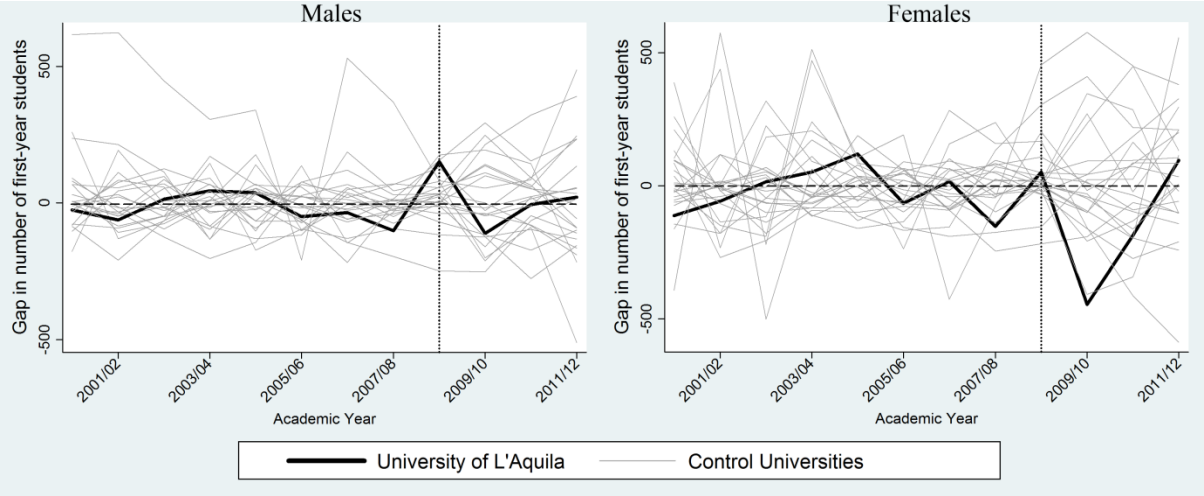
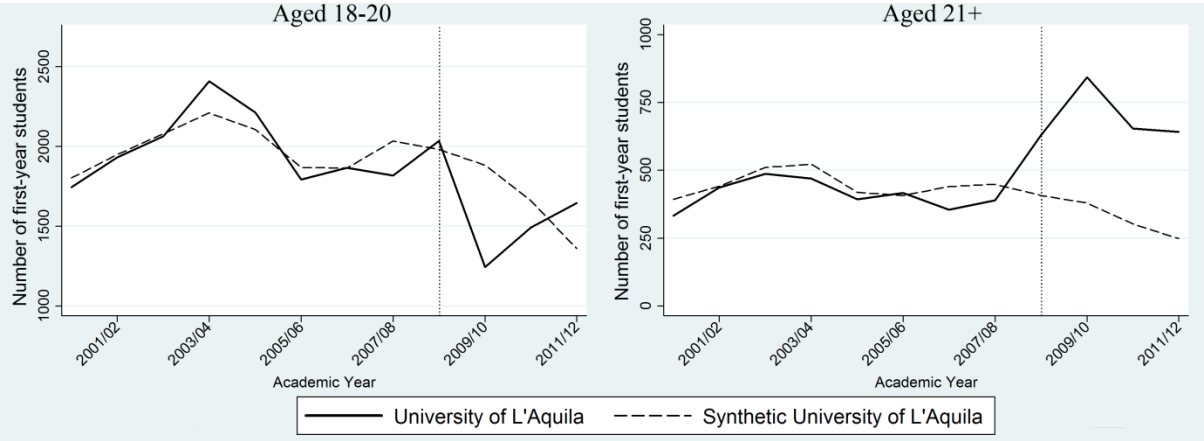


Fig. 7 Synthetic control results by age, academic years 2000/01-2011/12

Number of first-year students by age at the University of L'Aquila and at the synthetic comparison group



Number of first-year students' gap by age at the University of L'Aquila and placebo gaps by age at control universities

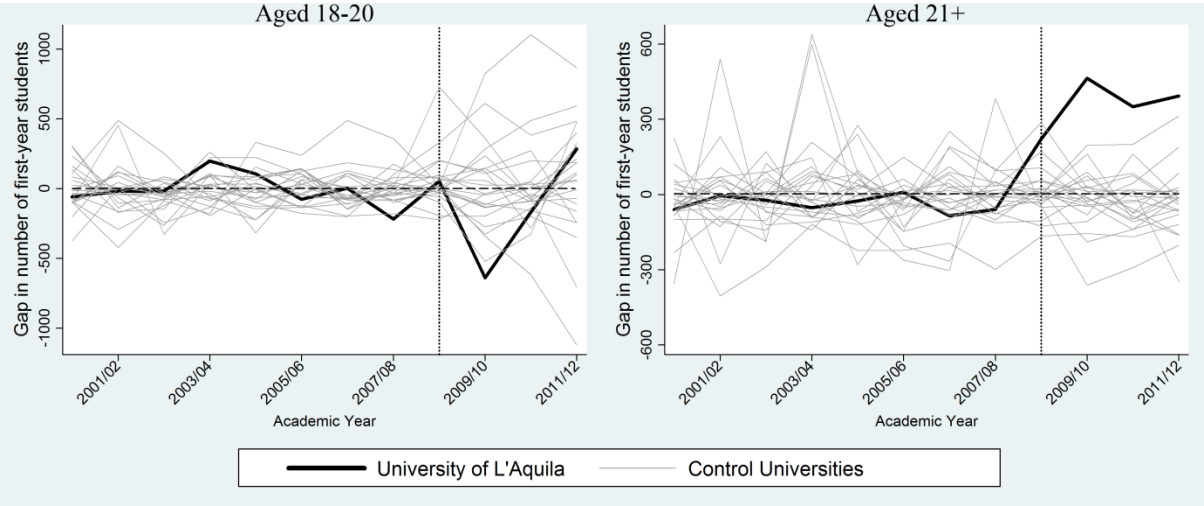
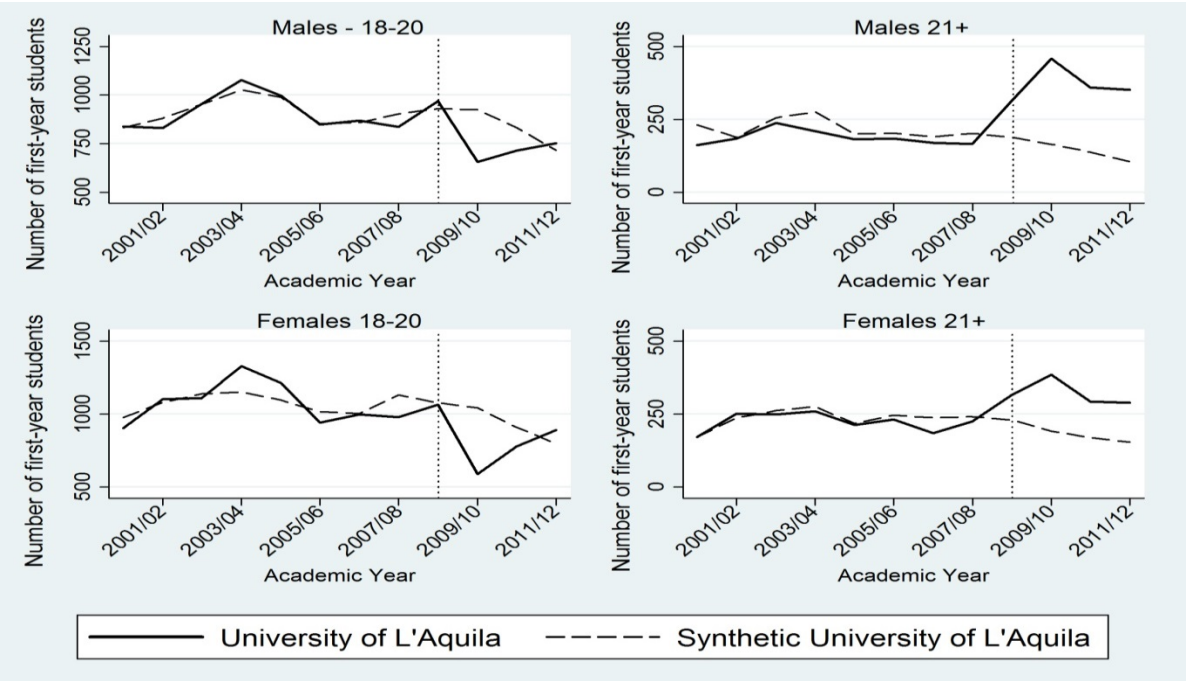


Fig. 8 Synthetic control results by gender and age, academic years 2000/01-2011/12

Number of first-year students by gender and age at the University of L'Aquila and at the synthetic comparison group



Number of first-year students' gap by gender and age at the University of L'Aquila and placebo gaps by gender and age at control universities

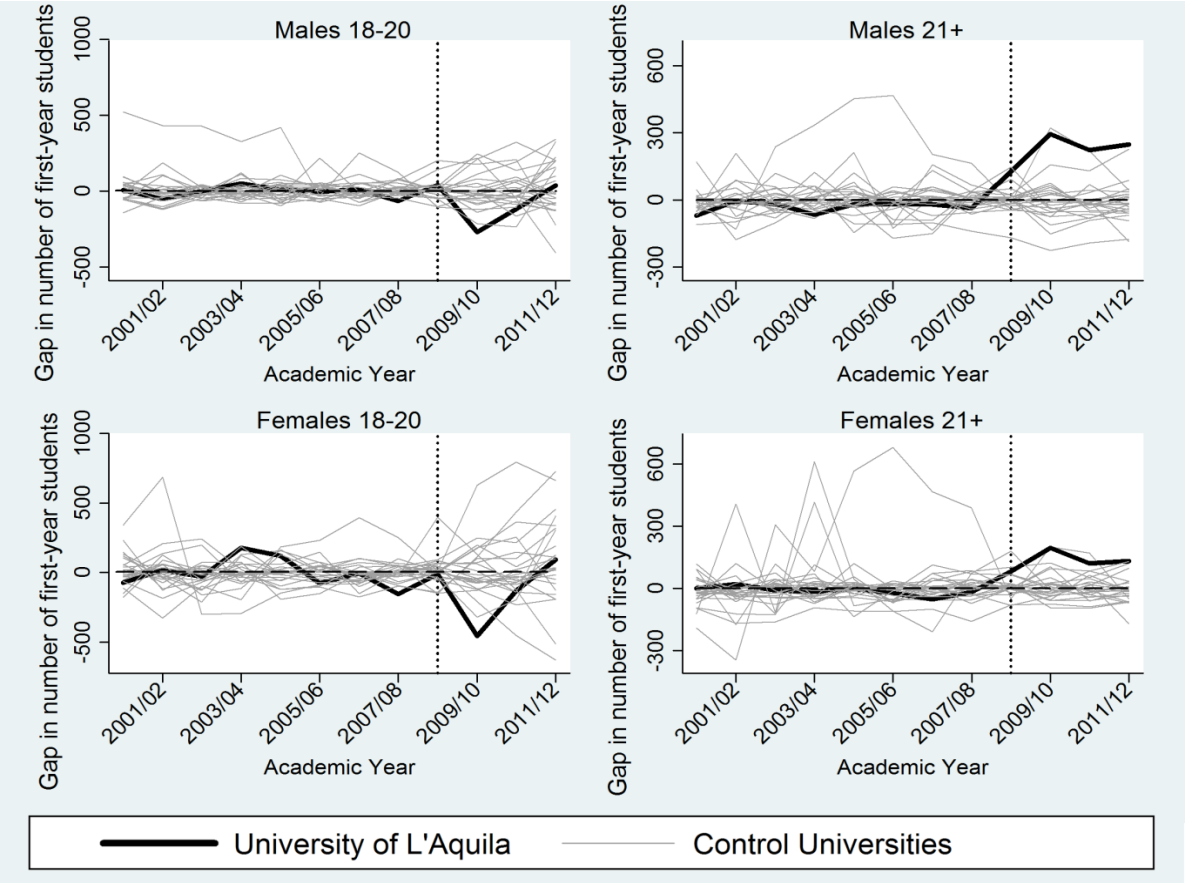


Fig. 9 Histogram of average placebo effects

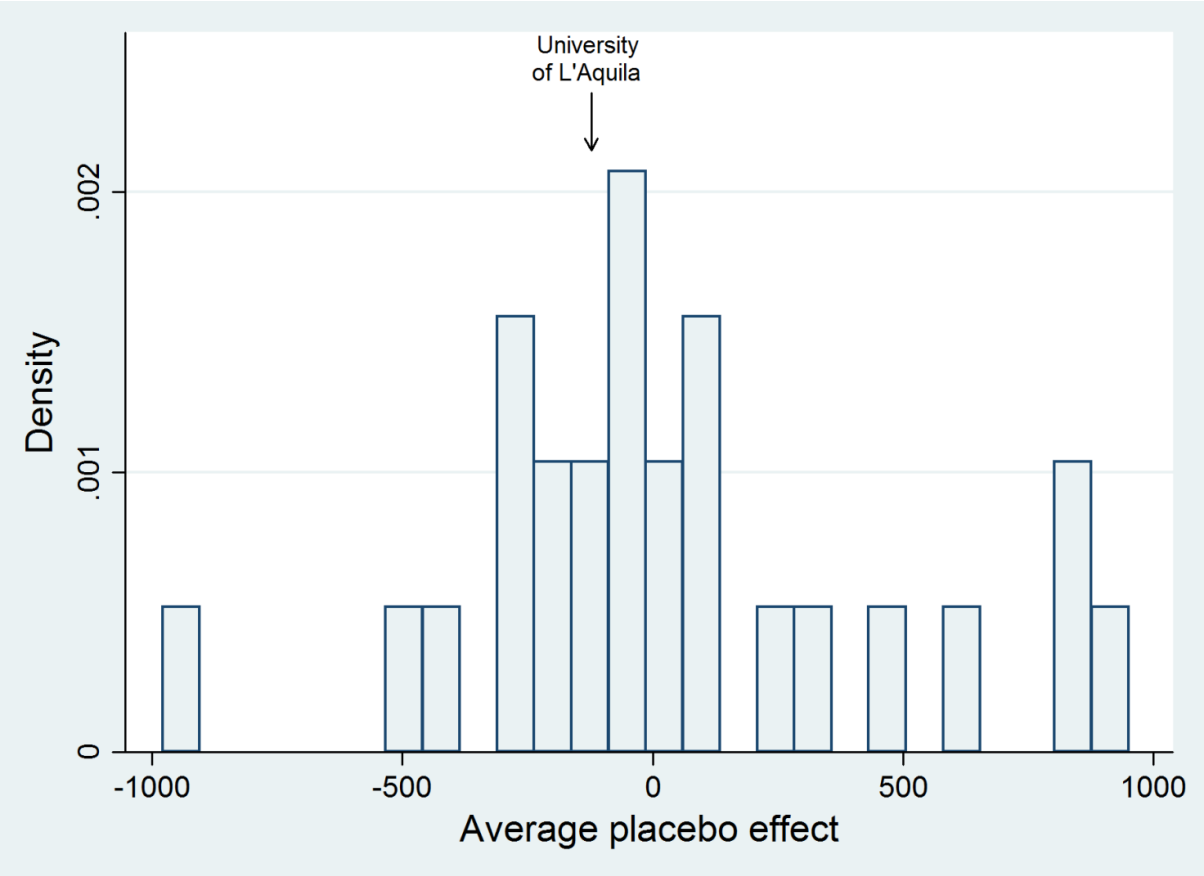


Fig. 10 Histogram of ratios between post-earthquake MSPE and pre-earthquake MSPE

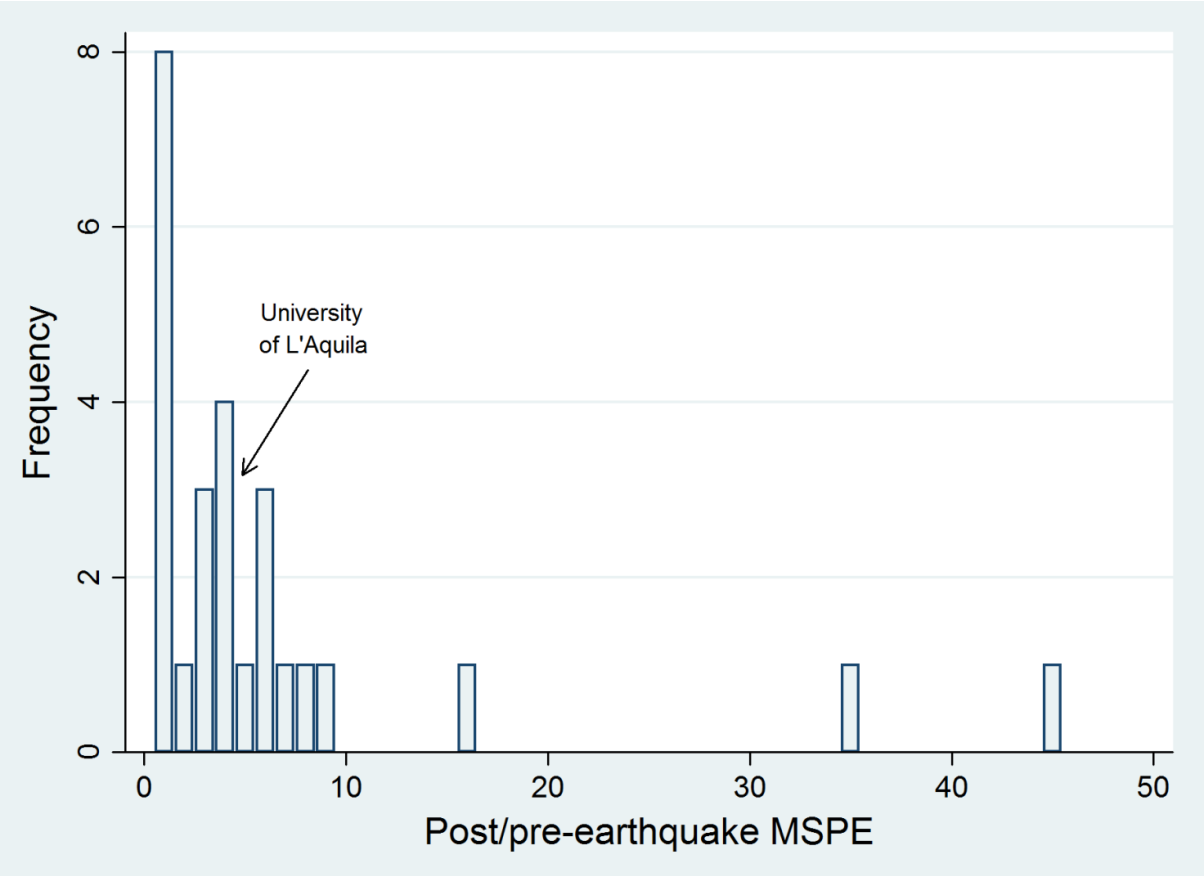
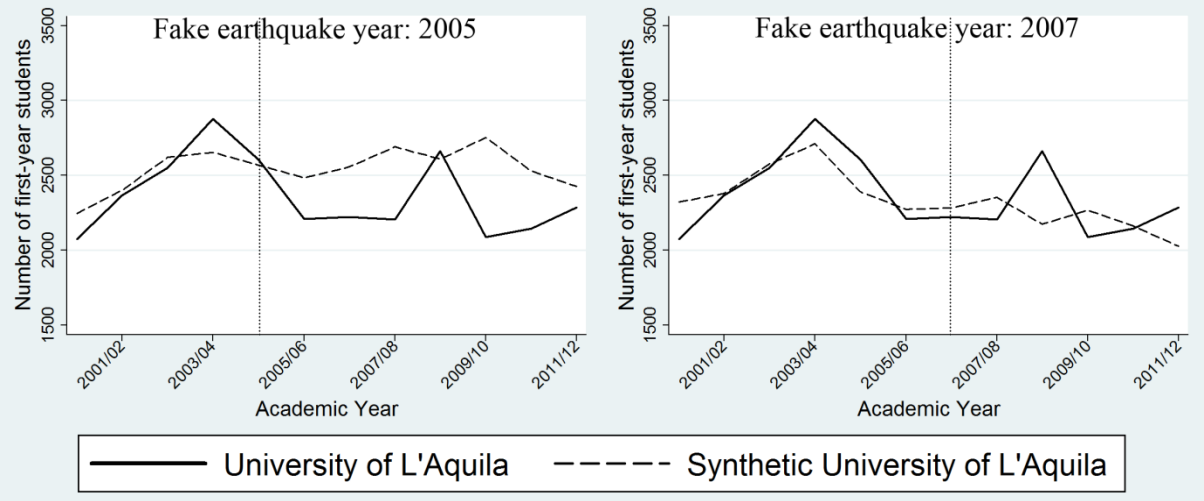
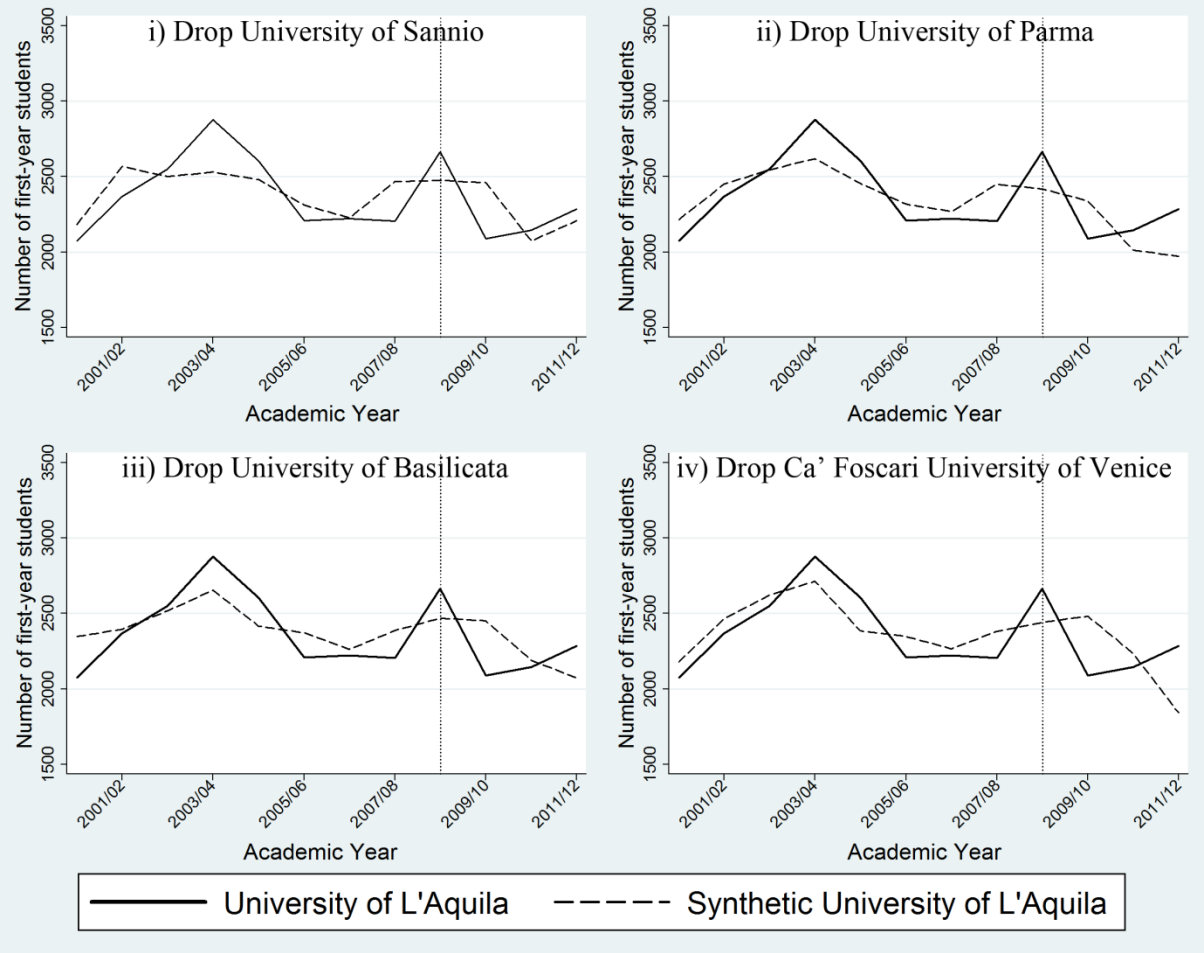


Fig. 11 Number of first-year students at the University of L'Aquila and at the synthetic comparison group, in-time placebo tests.



Note: The synthetic controls are made up by Polytechnic University of Marche (0.584), University of Sannio (0.331), University of Perugia (0.085) when the fake earthquake year is 2005 and Polytechnic University of Marche (0.094), University of Sannio (0.590), University of Perugia (0.111), University of Pavia (0.111), Carlo Bo University of Urbino (0.014) when the fake earthquake year is 2007.

Fig. 12 Number of first-year students at the University of L'Aquila and at the synthetic comparison group, Jackknife.



Note: Weights assigned to each university in the synthetic control for the University of L'Aquila after the dropping of each one of the universities receiving a positive weight in the main analysis.
i) Drop University of Sannio: University of Basilicata (0.472), Ca' Foscari University of Venice (0.363), Polytechnic University of Marche (0.065) and the Second University of Naples (0.100);
ii) Drop University of Parma: University of Basilicata (0.359), Ca' Foscari University of Venice (0.290), Polytechnic University of Marche (0.069), University of Sannio (0.155) and University of Salento (0.127);
iii) Drop University of Basilicata: Ca' Foscari University of Venice (0.263), University of Sannio (0.443), University of Foggia (0.112), University of Parma (0.156) and University of Sassari (0.026);
iv) Drop Ca' Foscari University of Venice: University of Basilicata (0.309), University of Sannio (0.251), University of Foggia (0.054), University of Parma (0.293) and University of Insubria (0.093).