THREE ESSAYS ON ADVERSE EVENTS AND STUDENT OUTCOMES

by

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IDI DISCLAIMER

Access to the anonymised data used in this study was provided by Statistics New Zealand in accordance with security and confidentiality provisions of the Statistics Act 1975. The findings are not Official Statistics. The results in this paper are the work of the authors, not Statistics NZ nor the Ministry of Education, and have been confidentialised to protect individuals from identification. The results are based in part on tax data supplied by Inland Revenue to Statistics NZ under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form, or provided to Inland Revenue for administrative or regulatory purposes. Any person who has had access to the unit record data has certified that they have been shown, have read, and have understood section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements.

ABSTRACT

This dissertation contains three essays on the impact of unexpected adverse events on student outcomes. All three attempt to identify causal inference using plausibly exogenous shocks and econometric tools, applied to rich administrative data.

In Chapter 2, I present evidence of the causal effects of the 2011 Christchurch earthquake on tertiary enrolment and completion. Using the shock of the 2011 earthquake on high school students in the Canterbury region, I estimate the effect of the earthquake on a range of outcomes including tertiary enrolment, degree completion and wages. I find the earthquake causes a substantial increase in tertiary enrolment, particularly for low ability high school leavers from damaged schools. However, I find no evidence that low ability students induced by the earthquake complete a degree on time.

In Chapter 3, I identify the impact of repeat disaster exposure on university performance, by comparing outcomes for students who experience their first earthquake while in university, to outcomes for students with prior earthquake exposure. Using a triple-differences estimation strategy with individual-by-year fixed effects, I identify a precise null effect, suggesting that previous experience of earthquakes is not predictive of response to an additional shock two years later.

The final chapter investigates the impact of injuries sustained in university on academic performance and wages, using administrative data including no-fault insurance claims, emergency department attendance and hospital admissions, linked with tertiary enrolment. I find injuries, including minor injuries, have a negative effect on re-enrolment, degree completion and grades in university.

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1 INTRODUCTION

This dissertation contains three essays on the impact of unexpected adverse events on student outcomes. All three attempt to identify causal inference using plausibly exogenous shocks and econometric tools, applied to rich administrative data. They are all co-authored with my supervisor Harold Cuffe.

The second chapter presents an analysis of a major earthquake on high schoolers' university enrolment. In 2011, the Christchurch earthquake caused severe disruption to homes, schools, and city-wide infrastructure. We measure the impact of the earthquake by comparing tertiary education enrolment for high school leavers affected by the earthquake to high school leaver enrolment prior to the earthquake. We use rich student level data, and include high school fixed effects models to restrict variation to within school changes. We identify a causal effect using plausibly exogenous variation in the level of damage to each school. On average, we find that attending a school damaged by an earthquake raises school leavers' tertiary enrolment rates by 6 percentage points. We find the effect is greatest for lower academic ability students, who increase tertiary enrolment by 8 percentage points. However, for the subsample of lower ability high school leavers, we find no increase in degree completion. We interpret this increase in enrolment rates, without a corresponding increase in degree attainment, as evidence supporting that lower ability high school leavers induced into university by the earthquake are not likely to complete their degree.

In chapter three, we investigate whether repeat exposure to earthquakes affects students differently, compared to those who experience their first earthquake. In 2013, Victoria University of Wellington (VUW) was affected by two large earthquakes, which caused disruption to the university and students. We identify whether students who previously attended high school in Canterbury, and therefore likely experienced the 2011 Christchurch earthquake, are affected differently to students from other regions, using course-level data from VUW. Using a triple-differences estimation strategy with individual-by-year fixed effects, we identify a precise null effect, suggesting that previous experience of earthquakes is not predictive of response to an additional shock two years later. We show our results are not driven by a change in sample caused by the 2011 earthquake.

The final chapter identifies the impact of injuries on student performance using administrative data including no-fault insurance claims, emergency department attendance and hospital admissions, linked with tertiary enrolment. While a broad literature assesses the impact of injuries on wages and employment, we are the first to identify the effect on student outcomes, including passing courses, re-enrolment and degree completion in university. We find that injuries negatively affect all student outcomes, causing decreases in re-enrolment by 4 percentage points, and degree completion by 3.4 percentage points for first year students. We also investigate heterogeneous effects of injuries, by timing, part of the body, and cause.

2 OPPORTUNITY FROM DISASTER: THE EFFECTS OF THE CHRISTCHURCH EARTHQUAKE ON HIGH SCHOOLERS' POST-GRADUATION OUTCOMES

Introduction

Between 1998 and 2017, weather or geo-physical disasters killed 1.3 million people and left a further 4.4 billion injured, homeless, displaced or needing emergency assistance (UNISDR 2018). As weather patterns become more extreme due to climate change, disasters are predicted to occur with increasing frequency and severity, posing a growing threat to populations in both developed and developing countries (O'Neill et al. 2017). Given this forecast, understanding how disasters affect education attainment is a major public policy concern. In a recent paper, Deryugina, Kawano, and Levitt (2018) find that Hurricane Katrina has long term positive effects on victims' incomes, and posit that increased educational investment may be one consequence of the disaster. Sacerdote (2012) finds Hurricane Katrina increases university attendance, particularly among suburban youth. Sacerdote surmises that "labour market disruptions caused students to choose college attendance over the labour force."

We consider the hypothesis that disasters increase education investment by estimating the causal effects of a major earthquake on university enrolment decisions in New Zealand. We show that, like the Katrina evacuees, high school students respond to the Canterbury earthquake with greater university attendance, especially among low-ability students. Unlike Sacerdote (2012), we can track students many years after university enrolment. Despite the increase in university attendance, degree completions fail to rise, indicating a lack of tertiary education success by the additional enrolees. Likewise, we find no change in the probability that these students go on to work in industries associated with holding a university degree. We conclude that for many students who graduate high school and are faced with a disrupted labour market, university may serve as a fall-back option where low-interest rate loans and government allowances are easily accessed. While we cannot conclude whether these university attendees who fail to obtain a degree would have been better off not enrolling, the significant financial cost of tertiary education, both directly and in terms of labour forgone, suggests there are negative economic implications for affected students. Identifying the impact of failing to complete a degree on outcomes such as health and income would be a valuable future research topic.

To understand how disasters affect student outcomes, we use administrative education and tax data covering all New Zealanders. We compare tertiary education and employment outcomes for high school graduates from damaged and undamaged schools in earthquake affected regions, separately. Prior cohorts, and graduates from schools in the rest of the country, serve as counterfactual groups.

Our comprehensive linked panel data, and the unanticipated nature of the earthquake, provide a unique opportunity to overcome two known challenges facing disaster-related work (Callen, 2015). Firstly, there may be selective exposure to a disaster. For example, the predictable nature of hurricanes provides an opportunity to evacuate the area before the event, resulting in different levels of disaster exposure depending on individual ability and willingness to relocate. We argue that since the New Zealand earthquake strikes an area previously thought to be low earthquake risk, it provides a natural experiment for estimating causal effects that avoids bias from selection out of exposure. Secondly, selective migration away from affected areas after a disaster can result in a sample of data which only includes people who choose to stay in the region. Our administrative data covers the entire population. Therefore, we can identify all students attending schools in the affected region at the time of the earthquake, and follow those who migrate after the disaster. This allows us to overcome estimation bias from selective migration.

While we study the effects of an earthquake, our research relates to the broader literature on the impact of disasters on students. Most relevant is Sacerdote (2012), who investigates the impact of Hurricanes Katrina and Rita on academic performance and college enrolment for evacuated high school students using administrative data. Sacerdote (2012) finds that while evacuated students see an initial decline in test scores, they experience a positive effect after two years. He shows that evacuees from New Orleans' suburbs enrol in tertiary education at greater rates than pre-hurricane cohorts, and argues that disrupted labour markets may be the reason for this increase.

Research on the impact of other disasters on education outcomes includes Holmes (2002), who finds that extreme storms in North Carolina negatively affect the test scores of elementary and middle school students. Pietro (2018) analyses the impact of an earthquake in Italy, and finds that experiencing the disaster increases the probability that university students do not graduate on time. However, Doyle, Lockwood, and Comiskey (2017) find that hardship for university students caused by Superstorm Sandy, including days without power, missed classroom instruction and displacement, has no significant relationship with academic achievement. They argue this result may be because university students are insulated from the worst effects of disaster, since they typically do not own their homes and the university can provide support in the aftermath.

To our knowledge, there are three other quantitative studies on the effect of Christchurch earthquake on student performance. Kemp et al. (2011) use administrative data from the University of Canterbury to identify the impact of the 2010 earthquake on tertiary students, and find the earthquake has no effect on academic performance or course withdrawals for enrolled tertiary students. Beaglehole et al. (2017) use national data on NCEA attainment and school rolls to identify the impact of the earthquake on high school students, and find no effect. Connolly (2013) focuses on the impacts of the earthquakes on educational inequalities and achievement in Christchurch high schools, and finds the 2010 earthquake had a larger negative effect for students attending schools in lower socio-economic catchment areas. However, the author finds the 2011 earthquake did not disproportionately affect these schools. In addition, there are two qualitative studies which complement our findings. Pine (2015) interviews secondary school students who experienced the earthquake, and documents students' perspectives on school support and recovery. Ham et al. (2012) provide an in-depth overview of school site-sharing arrangements following the earthquake.

Background

The Christchurch Earthquake

Earthquakes are a known risk in New Zealand, which sits on several major fault lines. However, prior to the Christchurch earthquake, public attention was focused on preparing for a seismically 'overdue' rupture along a major fault line elsewhere on the South Island, and on improving resilience in the earthquake-prone capital city 300 kilometres to the north. Therefore, it was entirely unexpected when, on 4 September 2010, a large earthquake of magnitude 7.1 occurred in Canterbury, an area which was previously classified as the lowest earthquake risk according to New Zealand building standards. The Canterbury region spans the east coast of New Zealand's South Island, and includes Christchurch, which was the second largest city in New Zealand at the time of the earthquake. Before the disaster, Christchurch had a population of 386,000; for comparison with Hurricane Katrina, this is about 100,000 fewer residents than pre-hurricane New Orleans.

The 2010 tremor occurred at 4.35am, when most residents were away from Christchurch's high-rise city centre. It caused structural damage but few casualties. In the subsequent months, several major aftershocks struck the area. On 22 February 2011, the most destructive aftershock struck within ten kilometres of the downtown area. This tremor, termed the 2011 Christchurch Earthquake, occurred on a Tuesday at 12.51pm, when the city centre was at its busiest. With infrastructure already weakened, the quake caused several buildings to collapse, killing 185 people and injuring thousands more.

Residents and the local government were unprepared for the scale of the disaster. Liquefaction, a process which temporarily turns solid ground to liquid, caused widespread damage to the city, burying streets and causing buildings to sink. Underground infrastructure was damaged, resulting in lifeline failure and waterways contaminated with untreated sewage. The disaster damaged nearly 170,000 houses, which constituted three quarters of the housing stock in the region, and 10,000 homes had to be demolished. The number of building, land and contents claims exceeded 700,000, twice the amount the state-run Earthquake Commission (EQC) expected from a 'worst foreseeable event' (King et al. 2014). In 2016, the Reserve Bank of New Zealand calculated the rebuild cost to be $28 billion,[1] and estimated the rate of ongoing rebuild activity to be 1.5 percent of potential GDP per year (Wood, Noy, and Parker 2016).

The earthquake caused extensive damage to schools. Because the New Zealand school year runs from February to December, students were immediately subject to ongoing hardship and recovery efforts. Several initiatives were taken to reduce the disruption to students. 18 schools were relocated, and 7,000 students were bussed daily to host sites. 55 percent of high school students were 'site sharing', with one school holding classes in the mornings and another school holding classes in the afternoons (Potter et al. 2015). Over 12,000 students left their school and enrolled elsewhere, including in schools outside the region, although most of these students returned within the year.

Several allowances were made for high school students given the circumstances they faced. In 2011, the New Zealand Qualification Authority permitted schools to apply for 'earthquake

[1] All dollar amounts in the paper are in US dollars, adjusted to 2019 prices.

impaired derived grades' on national standards tests and, in some cases, awarded supplementary school credits to students.[2]

Education in New Zealand

To assess the generalisability of our results, it is important to understand the educational context of New Zealand students. 96 percent of secondary school students attend state schools,[3] with the remaining 4 percent attending private or boarding schools. We restrict our analysis to all students from state schools, because private schools tend to offer alternative assessment methods for which we have no data.

Students enter high school between ages 12 – 13 and graduate between ages 17 – 18. Schooling is compulsory until age 16, but most students remain throughout the final year. For perspective, in 2017 only 16.5 percent of students dropped out of school early (Ministry of Education 2017). In students' final three years of school, they work towards the 'National Certificate of Educational Achievement' (NCEA) qualification Levels 1, 2 and 3. Students gain credits for 'standards' throughout the year, assessed through assignments and exams, which contribute to the award at each level.

There are eight public universities and sixteen public polytechnics in New Zealand, which covers 85 percent of tertiary study in the country (Ministry of Education 2018). A full time Bachelor's degree typically takes three years to complete. The Canterbury region includes two universities; the University of Canterbury and Lincoln University. There is one main polytechnic, and the satellite campuses of four other polytechnics in the region.

Overall, the educational context is similar to most developed countries. High school students are examined between the ages of 16 – 18, and gain entry to tertiary education based on these results. Cost to students likely represents the largest difference between New Zealand and U.S. university systems. Annual university tuition fees were approximately US$3,500 per year in 2011, less than half the average annual tuition fee in the U.S in the same year (OECD 2011). All New Zealand university students have access to government loans and many receive publicly provided allowances after graduating from high school. This access to finance might

[2] In 2011, high school seniors could apply to receive six senior-level high school credits. Graduates need a minimum of eighty to enter university. According to Beaglehole et al. (2017), information on how earthquake derived grades were assigned was not stored in a consistent and recoverable way.

[3] This includes eleven percent of students attending state integrated schools, which have a religious or particular learning philosophy, but operate as state schools.

make the decision to enrol more likely for people on the margin, relative to people in countries where students bear a greater share of the costs.

Data

We draw data from the Integrated Data Infrastructure, a large research database containing detailed administrative data on all New Zealanders, linked at the individual level. We identify students in their senior year as those who take NCEA Level 3 credits for the first time between the years 2008 and 2013, aged 17-19. While these criteria do not identify all students enrolled as seniors, because students are not required to participate in NCEA assessment, it captures most students in the cohort. In New Zealand, there are fourteen high schools which offer International Baccalaureate, an alternative credential to NCEA, and only one of these is in Christchurch. In addition, New Zealand Qualifications Authority data shows that in 2014, 80 percent of enrolled senior students attempted NCEA Level 3 (NCQA 2014). We provide evidence that students do not select out of NCEA into alternative qualifications following the earthquake, by comparing NCEA completion in damaged and undamaged schools, before and after the earthquake.

We restrict our analysis to the 2008 – 2013 cohorts as the data contains complete information about school enrolment from 2008 onwards. The upper limit of 2013 allows enough time after high school completion for most tertiary decisions to be made and recorded in the data, and for post-university careers to begin. We define the 'treatment group' as students who either graduate from a Canterbury high school prior to the disaster, or are enrolled in a high school in the Canterbury region on the date of the earthquake, 22nd February 2011. This definition of treatment encompasses people who migrate away from Canterbury in response to the disaster. If we instead define treatment as simply graduating from a Canterbury high school, we may falsely attribute changes in outcomes to the disaster when they are instead caused by compositional change in the remaining population of Canterbury students.

We divide all students into one of three categories based on the extent of damage sustained in the area surrounding their high school. School exposure to the disaster is determined using categorisation of ground movement and area damage found in Potter et al. (2015), and school closure reports (Ham et al. 2012). We assign high schools to one of three levels of exposure; not in Canterbury (*Non-Canterbury)*; in the region but not in damaged areas (*Undamaged)*; or in the region and in damaged areas (*Damaged*). Table 2.1 gives the criteria for each student's exposure based upon his or her high school. For brevity, we refer to high schools in damaged areas as *damaged*, and schools in undamaged areas of Canterbury as *undamaged*.

The resulting sample captures 134,559 high school seniors from 2008 – 2013. Table 2.2 shows summary statistics for the whole sample, and by level of exposure to the disaster. Overall, 58 percent are female, which agrees with a documented gender gap in high school completion (Ministry of Education 2017). 5.6 percent of the sample attend undamaged schools in Canterbury, and 6.6 percent attend damaged schools in Canterbury. Indicators for ethnicity are not mutually exclusive.

Secondary school enrolment data includes information on the specific school attended, location, dates enrolled, and qualifications achieved. This data is matched to tertiary enrolment data, which includes the institution and campus location, date enrolled, degree title and individual course registration. 73 percent of seniors enrol in tertiary education within two years of leaving school. Students from undamaged schools in the region enrol in tertiary education at a lower rate than the other groups, at 67 percent.

We investigate early career earnings and industry of work using individual tax returns. In Table 2.2, we report average monthly earnings five years after leaving high school. Overall, 82 percent of the sample are matched to positive wage earnings. Possible reasons for not matching are that the student has no income, or has income from other sources, such as wages earned overseas, interest or dividends. Average monthly earnings calculated using tax returns data is $1,401 for those outside of Canterbury, $1,537 for those from undamaged schools and $1,375 for those from damaged schools.

Empirical Strategy

In the simplest OLS specification, we investigate the effects of the disaster on high schoolers' tertiary enrolment decisions, compared to students from unaffected schools in the rest of the country over the same period.

$$y_{ics} = \sum_{\substack{d \in (Damaged, \\ Undamaged)}} (\beta^d \, d_s \times Post_c) + \alpha_c + \sigma_s + \boldsymbol{x}_i{}'\Pi + \varepsilon_{ics} \qquad (2.1)$$

i, c and s index individuals, graduating cohort (e.g. the class of 2009) and school respectively. In equation (2.1), we allow the treatment effect to vary by disaster exposure, using the school damage categories detailed in Table 2.1, and $Post$ is an indicator equal to one if the student finishes high school in years 2011 – 2013. β is the coefficient of interest, which identifies the causal effect of experiencing the disaster as a high school student, compared to other recent high school graduates. To relax the assumptions necessary for identification and reduce residual variance, we include cohort and high school fixed effects α_c and σ_s. Thus, we are restricting attention to within-school across-time variation in outcomes, after accounting for broader year-to-year changes in university-going rates. This strategy accounts for omitted variable bias from factors which could correlate with both the outcome variables, and the $d_s \times Post_c$ indicator, such as school openings or closures, or swings in the macroeconomy. Controls for gender and ethnicity are included in the column vector $\boldsymbol{x}_i$. We estimate standard errors that account for clustering at the high school level.

We also estimate a more flexible version of equation (2.1) which allows the treatment effect to vary for each cohort:

$$(2.2) \qquad y_{ics} = \sum_{\substack{d \in (Damaged, \\ Undamaged)}} \sum_{t=2009}^{2013} (\beta^{d,t} d_s \times 1[c = t]_c) + \alpha_c + \sigma_s + \boldsymbol{x}_i{}'\Pi + \varepsilon_{ics}$$

In equation (2.2), we interact indicators for school damage levels with an indicator for each cohort's high school graduation year. The omitted category is the 2008 cohort.

Results

Education Outcomes

Table 2.3 presents our results for the impact of the earthquake on tertiary enrolment. Panel A gives the effects of the earthquake on four tertiary education outcomes for all Canterbury students, pooling damage categories 'undamaged' and 'damaged'. Each column corresponds to a different outcome variable, which are all indicators equal to one if within two years of high school graduation the student (1) enrols in any public tertiary education; (2) enrols in one of the eight large universities; (3) enrols in a polytechnic; and (4) enrols in a STEM major.[4] We distinguish between the large universities and polytechnics because the disaster may affect their enrolment rates differently. For example, the disaster may force substitution across tertiary

[4] Gap-years where people delay entry into university to work or travel are common in New Zealand (Engler 2010). The 2-year post-graduation window allows for a delay by recent graduates (particularly those immediately affected by the disaster) before making tertiary education enrolment decisions. Figure 2.2 shows the results for tertiary enrolment within one year. The conclusions from both figures do not meaningfully differ.

qualifications, encouraging greater enrolment in polytechnics which emphasise trade skills necessary for disaster recovery, rather than universities that mainly offer less vocational Bachelor's degrees. Mean polytechnic enrolment is low at around 7 percent, which may reflect that many polytechnic degrees do not require NCEA Level 3 achievement. Similarly, we include STEM enrolment as an outcome because it may indicate changes in career paths following the disaster.

We find the disaster has significant positive effects on tertiary enrolment. In Table 2.3 Panel A, students from Canterbury who finish high school after the earthquake are 2.7 percentage points more likely to enrol in tertiary education, which represents a 3.7 percent increase over the mean attendance rate of Canterbury cohorts that graduate before the disaster. This effect is only statistically significant for polytechnic enrolment, which increases by 1.3 percentage points ($p < 0.01$). We estimate a precise null effect on STEM enrolment, suggesting that the students induced into tertiary education by the disaster are not choosing STEM subjects at rates markedly different than earlier cohorts.

Table 2.3 Panel B illustrates the effects of the disaster, stratified by high school area damage. The effect on both university and polytechnic enrolment is greater for students from damaged high schools than students from undamaged local high schools, and from high schools elsewhere in the country. Enrolment in tertiary education increases by 5 percentage points for damaged schools (3.2 and 1.9 percentage points for university and polytechnic enrolment, respectively). Coefficients are small and statistically insignificant for students from undamaged schools in the area.[5] As seen in the summary statistics, pre-earthquake tertiary enrolment patterns differ across students in damaged and undamaged high schools, with students from damaged high schools more likely to attend universities than students from undamaged schools, and students from undamaged schools more likely to attend polytechnics than students from damaged schools. This feature means that the percent impact on polytechnic enrolment for students from damaged high schools is substantial, and the effect represents a 29 percent increase over enrolment rates observed for 2008-2010 cohorts. Again, we find no meaningful impact on STEM degree enrolment rates.

[5] Hypothesis tests of the equality between the coefficients for 'Damaged × Post' and 'Undamaged × Post' show they are statistically significantly different from each other at the 5 percent level for all tertiary enrolment (column 1), and university enrolment (column 2).

Dynamic Effects on Tertiary Outcomes

Figure 2.1 summarises the effects of the disaster on tertiary outcomes with the dynamic specifications of equation (2.2). All coefficients are in relation to the omitted 2008 cohort, allowing the treatment effect to vary by exposure and year. The change in magnitude and statistical significance of the coefficients from 2011 onwards aligns with the timing of the earthquake, illustrating a discrete change in behaviour for those cohorts who experience the earthquake as high schoolers. Here, we see a sustained increase in tertiary enrolment for students who attend damaged schools, by 6 percentage points ($p < 0.01$) for students graduating in 2011, 6.9 in 2012 ($p < 0.01$) and 4.5 in 2013 ($p < 0.05$). Interestingly, students who attend undamaged schools in the region have mostly small and statistically insignificant changes in tertiary enrolment. For robustness, Figure 2.2 shows the coefficients for equation (2.2) when the outcome is an indicator for enrolling in tertiary education within one year. Using this specification, we find similar results. These results are in line with Sacerdote (2012), who finds suburban school leavers following Hurricane Katrina increase enrolment in university by between 2.5 – 3.4 percentage points.

Heterogeneity across high school students

We expect the effect of the earthquake to be heterogeneous across gender and ability for at least three reasons. Firstly, different groups face different labour market disruptions, which alter the opportunity costs of university enrolment across groups. The resulting construction boom could encourage more low-skilled men to select out of university attendance, relative to high skilled men, or women, whereas declines in consumer spending hurt the retail sector which disproportionately employs women. Second, pre-disaster tertiary education uptake is not constant across groups. Low ability students are least likely to enrol in tertiary education prior to the earthquake, so the scope for an increase in enrolment is largest for this group. Finally, existing research finds differences in the psychological response to natural disasters among men and women (Zhou et al. (2013) and Wang et al. (2009)), with the severity and persistence of post-traumatic stress symptoms greater for women.

To investigate these potential sources of heterogeneity, we estimate the effects of the disaster on samples stratified by gender and academic ability. We measure academic ability in high school using expected percentile based on performance in NCEA Level 3 assessments. This measure converts a student's score in each NCEA standard into an expected percentile ranking across all students nationally, and calculates the average of these estimates over all standards taken. For our purposes, we transform the expected percentile to a within-school-cohort ranking of relative percentiles, and allocate students into low, middle or high relative ability terciles. We use this transformation because the disaster may have directly interfered with the students' performance on national exams, and there is no available record of which students received earthquake impaired derived grades. Therefore, it is unclear whether cross-sectional comparisons of students' percentile scores accurately depict academic ability during this time. We hope to avoid situations where short-term impairment on exam performance portray high ability students as low ability, or unobserved grading interventions imply the opposite. We therefore stratify students by their academic performance relative to same-school and cohort peers, under the assumption that the ranking of students within school-cohorts remains largely unaffected by the earthquake.

Effects of the earthquake on any tertiary education enrolment for stratified samples are shown graphically in Figure 2.3. In Panels A and B, we stratify by gender. For high school students from damaged schools, we see the impact of the disaster occurs later for men, with increases of 9.0 percentage points for the 2012 cohort only ($p < 0.01$). Women see increases of 7.1 ($p < 0.01$), 5.2 ($p < 0.05$) and 5.3 ($p < 0.1$) percentage points for 2011, 2012 and 2013 cohorts respectively. The absence of an effect on students from undamaged Canterbury high schools in Figure 2.1 does not appear to result from offsetting positive and negative effects among men and women, as neither group exhibits significant changes in enrolment rates over this time period. Given that the standard errors are larger for men, but the magnitudes between genders are comparable, we do not include gender stratification in the other results.

In Figure 2.3 Panels C to E, we stratify the sample by relative ability terciles. For students from damaged schools, we observe a similar pattern of positive effects on enrolment across all terciles, though the effects are statistically significant only for the highest and lowest ability groups. The disaster increases tertiary enrolment significantly for the low ability cohort, by 8.1, 11.1 and 9.8 percentage points in each post-disaster year. This magnitude is equivalent to a 13 – 18 percent increase compared with 2008 enrolment rates. Estimates for high ability students at damaged schools are smaller in magnitude, with increases of 6.2 and 5.3 percentage points in the years following the disaster, or a 6 – 7 percent increase above 2008 enrolment rates. Coefficients for undamaged schools are almost exclusively close to zero and are not statistically significant.

Early school leaving

We may be concerned that the results reflect disaster-related changes in the sample of students who remain in high school until their senior year. If disasters cause weaker students to drop out of school early, the remaining sample will be made up of stronger students who are more likely to enrol in tertiary education regardless of the disaster. Beaglehole et al. (2017) conclude that the earthquake has no impact on early secondary school leaving or academic performance. However, Beaglehole et al. (2017) use more limited school-level data without an ability to track migrating students. We consider the effects of the disaster on high school continuation in three ways. First, we aggregate the data at the school-by-cohort level and use a specification similar to equation (2.2) to estimate the dynamic effects of the disaster on the number of seniors enrolled at each school, in each cohort, y_{cs} :

$$(2.3) \qquad y_{cs} = \sum_{\substack{d \in (Damaged, \\ Undamaged)}} \sum_{t=2009}^{2013} (\beta^{d,t} d_s \times 1\,[c = t]_c) + \alpha_c + \alpha_s + \varepsilon_{cs}$$

Importantly, Figure 2.4 shows that the earthquake did not decrease the number of NCEA Level 3 students in senior cohorts at damaged Canterbury schools. Although the estimates are not statistically significant for undamaged Canterbury schools, the magnitudes suggest that the size of senior cohorts that graduate after the disaster decline by up to 14 percent, relative to the 2008 cohort.

Secondly, we construct a sample of all birth cohorts from 1990 – 1996, restricted to those with a recorded address at age 14 years. To understand whether high school students in Canterbury were less likely to complete NCEA Levels 1-3, which would indicate a selection of more ambitious students in Canterbury into our sample, we estimate the interaction between having an address at age 14 in Canterbury and each birth cohort, where the outcome is an indicator for (1) NCEA Level 1 by age 17; (2) NCEA Level 2 by age 18; and (3) NCEA Level 3 by age 19. In 2011, we would expect birth cohorts 1993-1994 to take NCEA Level 3. Table 2.4 shows the results.[6] Here, we see no statistically significant change on NCEA achievement for any birth cohort from Canterbury. If we assume that address at age 14 is a proxy for being a student in Canterbury at the time of the earthquake, this null result shows that NCEA Level 3 achievement

[6] Sample is larger than NCEA data because the only restriction is an address at age 14 and covers seven birth years, whereas our main sample identifies those who take NCEA Level 3 credits for the first time aged 17-19, over six years.

for students in Canterbury was not affected by the earthquake. This finding supports existing literature, which shows no change in NCEA achievement for high school students following the earthquake (Beaglehole et al., 2017).

However, demonstrating that students from Canterbury are just as likely to take NCEA Level 3 following an earthquake does not address the concern that the earthquake may affect the *composition* of students choosing to take NCEA Level 3. For example, if more higher ability students and fewer lower ability students remain in school, the increased proportion of higher ability students may instead drive the results. Therefore, we estimate the individual-level dynamic model on a sample of 225,942[7] high school juniors[8] with an outcome variable that is an indicator equal to one if a student is in the senior-level sample[9] in the following year. Here, year references the year students are in their junior year. We stratify the sample by relative ability at NCEA Level 2, to identify whether there is a change in the composition of students taking NCEA Level 3 in Canterbury. Figure 2.5 shows the results. Across all the various stratified samples in damaged schools, we do not observe a statistically significant change in senior enrolment. This result demonstrates that our findings are not driven by selection out of NCEA Level 3 by weaker students following the earthquake.

Interestingly, high school juniors from undamaged schools in the region appear more responsive to the disaster, decreasing their high school continuation rates by 3.9 percentage points in 2011. The effect for students from undamaged schools is driven by low ability students, who decrease senior year registration rates by 6 percentage points in 2011 ($p < 0.1$).

For students from damaged schools, these results alleviate the concern that selection out of high school completion underlies the increase in tertiary enrolment rates. Alternatively, for students from undamaged Canterbury schools, the early selection out of high school may affect the composition of high school seniors. Given that the disaster causes some academically weak students to drop out, the tertiary enrolment rates of the relatively strong post-disaster senior cohorts should appear to rise, all else equal. Therefore, the null effects on demand for tertiary education for this group seen in Figure 2.1 may in fact signal reduced demand for tertiary education from academically stronger students at these schools.

[7] In 2010, Ministry of Education statistics show that 70% of high school leavers attained at least NCEA Level 2, and 43% attained at least NCEA Level 3 (Ministry of Education 2020). This suggests that 62% of NCEA Level 2 students go on to take NCEA Level 3, which is in line with our sample size.
[8] Technically, juniors who take NCEA Level 2 qualifications.
[9] NCEA Level 3 qualifications.

University Entrance Qualification

It is informative to examine whether the rise in demand for tertiary education comes, at least in part, from better achievement in high school. To this end, we next consider the effects of the disaster on students' chances of achieving the qualification necessary to attend university. The 'University Entrance' qualification consists of completing NCEA Level 3, including credits for certain literacy and numeracy standards. We estimate the individual-level dynamic model stratified by relative ability, where the outcome is an indicator equal to one if the student achieves the qualification. Figure 2.6 Panel A shows that the disaster increases the university entrance qualification attainment rate only for students from damaged schools. For the 2011 cohort the earthquake raises the university entrance qualification attainment rate by 5.3 percentage points. Low ability students exhibit increased qualification attainment by 10.8 percentage points in 2011, a 15 percent increase compared to the 2008 cohort ($p < 0.05$). Medium ability students see an increase of 3.2 percentage points in 2010 ($p < 0.05$), and high ability students see increases of 2 – 3 percentage points each year from 2010 to 2013.

These results support that the increase in tertiary enrolment may be partly driven by more low ability students achieving the minimum requirements necessary to access higher education. Since the effects are most pronounced in the 2011 cohort, it is possible that the rising qualification attainment may partially reflect nominal (rather than real) improvements in performance as some of these students receive earthquake derived grades.

Tertiary education region

We can attempt to understand some of the motivations for enrolling in tertiary education by examining where high school graduates take up further study. If Canterbury students use further education to migrate away from disaster-prone areas, we expect to see lower enrolment in Canterbury and Wellington (the earthquake-prone capital) institutions. Instead, if the motivation is simply to leave damaged areas, then we expect to see enrolment decline in Canterbury, and rise in Wellington alongside other regions. In Table 2.5, we show that the disaster has no effect on local enrolment for students from damaged schools, and reduces local enrolment for students from undamaged schools by 5 percentage points. Canterbury students (particularly those from damaged high schools) increase their enrolment in tertiary education in other regions by 2-3 percentage points. Canterbury students from undamaged schools see smaller but statistically significant ($p < 0.05$) increases in enrolment in other regions. It is noteworthy that the largest increase in enrolment is in the Wellington region. Since this area is known to be at high risk for earthquakes, this increase suggests that many of the students leaving the disaster area are not doing so to minimise exposure to future quakes.

Tertiary education outcomes

While the disaster increases tertiary enrolment, it remains an open question whether the affected students have the same success once enrolled as previous cohorts. Since the earthquake disproportionately increases tertiary enrolment among academically weak students, it is possible that these students are not well prepared for higher study. We investigate this hypothesis using the individual-level dynamic model and two outcomes. Firstly, an indicator for whether the tertiary student re-enrols for a second year of tertiary study; and secondly, an indicator for completing a degree within four years after high school.

Figure 2.7 shows the results for enrolling in a second year of tertiary education. Since the outcome is conditional on enrolling in the first year, the sample is restricted to those who enrol in tertiary education within two years of leaving school. We find statistically significant decreases in tertiary continuation by 3.3 percentage points for 2011 school leavers from damaged schools. We also find a decrease of 3.7 percentage points for the 2009 cohort. One possible explanation for this is that 2009 school leavers were likely to be about to start their second year of tertiary education when the earthquake struck, affecting their decision to drop out. When stratified by relative ability, we see the greatest effect for low ability students from damaged schools in 2011, who fail to enrol in second year at a 7.6 percentage point higher rate ($p < 0.01$).

Figure 2.8 shows results for tertiary education completions within four years of leaving school, for the whole sample of high school seniors. We find no significant increase in tertiary qualification completions following the earthquake for all students from damaged schools, and a significant positive effect for high ability students only, who have an increased completion rate of 6.8 and 6.4 percentage points in 2011 and 2012 ($p < 0.05$). This is of similar magnitude to the increase in tertiary enrolment for high ability students, suggesting those high ability students induced into tertiary enrolment by the earthquake are also likely to complete their degree. However, we do not find a statistically significant effect for low ability students, indicating that low ability students induced into tertiary enrolment do not complete their degree.

Together, these results suggest that, of those students induced into university, only high ability students go on to complete their degree, whereas low ability students, while enrolling at a higher rate, did not see the same longer-term benefits.

Early career outcomes five years after high school graduation

Since we find mixed outcomes for student enrolment and completion following the disaster, it is informative to investigate whether there is an impact on early career outcomes. We use administrative tax data to identify wages and industry of work five years after completing high school. For example, the 2013 high school graduation cohort is matched with tax data from 2018. These results need to be interpreted with some nuance, as there are many ways the disaster may affect labour outcomes. Five years after leaving high school, all cohorts are 'treated' in different ways. For example, some of the 2008 cohort may be in their final year of tertiary education at the time of the disaster, and face a challenging labour market when they graduate, whereas many individuals in the 2011 cohort enter the labour force after several years of recovery. However, since we know the disaster has heterogeneous effects on tertiary enrolment, it is worthwhile investigating early career outcomes by subgroup.

To interpret our findings, it is important to understand the labour market context of Canterbury in the wake of the earthquake, relative to the rest of New Zealand. The local labour market impact of the disaster is well documented by Wood, Noy, and Parker (2016), who report an initial decline in employment by 5 percent in 2011 and 2012 in Canterbury, followed by a 16 percent rise, attributed to the demand for construction workers. Most additional workers come from within the Canterbury region. Wood, Noy, and Parker (2016) also find that the unemployment rate in Canterbury fell from 4.7 percent to about 3 percent by 2014, widening the gap in unemployment rates between Canterbury and the rest of New Zealand.

Table 2.6 shows the estimates from the dynamic specification where the outcome is average monthly earnings[10] over the year, five years after a student graduates from high school. For example, if a student finishes high school in 2010, we match her to total earnings in 2015, divided by number of months worked. For all students in column (1), we see no effect on wages for students from damaged or undamaged schools. When stratified by ability in columns (2) – (4), we see no change in earnings for low ability students from damaged schools, and a significant increase in earnings for the low ability 2010 undamaged school cohort, by \$168 (p

[10]'Earnings' includes wage and salary earnings, and does not include self-employment or student allowance.

< 0.01). One reason for this increase could be selection out of high school and into short-term lucrative construction work. For medium ability students, we see a statistically significant increase of $132 for students from damaged schools leaving school in 2011. We see no statistically significant change for higher ability students.

Of course, this result does not necessarily mean that students channelled into university enrolment by the disaster do not benefit from attending; having a degree may protect their earnings from an otherwise significant decline. Alternatively, high wages among non-attendees participating in the rebuild may have offset the relatively low earnings of recent or soon-to-be graduates who anticipate better career trajectories. Given the results, it seems plausible that earthquake-induced low-ability university attendees find themselves on a similar earnings track as prior cohorts, as we would not expect to find economic benefits for students who enrol but fail to complete a degree.

We next consider the impact of the earthquake on industry of work five years after high school graduation. Since we observe more students enrolling in university, it is informative to identify if students are more likely to enter a profession which requires a tertiary degree. Industry is recorded in the tax data according to The Australian and New Zealand Standard Industrial Classification (ANZSIC). In total, there are 85 industry classifications, identified using two digits of ANZSIC. We estimate coefficients on dummy variables for each industry[11], where the outcome is an indicator for whether the students has completed a degree within four years of graduating high school, using a sample restricted to those who did not attend high school in Canterbury. We use the coefficients to rank the industries in order of most- to least- likely to require a degree. Students are categorised as working in a top 50th percentile industry if, five years after graduating high school, they are working in an industry in the top 50th percentile according to the ranking, unweighted by industry size. We estimate the dynamic model using the whole sample, where the outcome variable is an indicator for whether the high school leaver is working in a top 50th percentile industry five years after leaving school.

Figure 2.9 shows the results. Panel A shows there is a statistically significant positive effect for all cohorts from damaged schools, relative to 2008. One possible reason for this could be the affected labour market after the earthquake. Panel B shows an increased probability of being in a top 50 industry by 3.5 percentage points for the 2012 cohort only ($p < 0.05$). When

[11] If the student is employed in two or more industries, the indicator variable is equal to 1 for each industry of employment.

stratified by relative ability, high ability students are the only group to see a statistically significant effect, with increases of 6.7, 4.6 and 4.1 percentage points for cohorts 2011 – 2013. This is in line with our tertiary completion findings, where high ability students induced into university go on to complete their degree, but low ability students do not. Interestingly, Deryugina, Kawano, and Levitt (2018) hypothesise that the positive long term effect of Hurricane Katrina on victims' incomes may be driven by higher education uptake. We find that while the Christchurch earthquake did increase education uptake, this did not translate into higher incomes.

Conclusion

The 2011 Christchurch earthquake massively and unexpectedly disrupted the lives of local high school students. Schools were closed, and households faced uncertain financial circumstances brought on by lost assets and slow insurance settlements. We build on existing literature which finds a positive long-term impact of disasters on income and employment, and find the earthquake causes students from schools in damaged areas to enrol in tertiary education at a higher rate. This effect is largest for low ability students, and is not driven by compositional changes in high school graduation rates. However, once enrolled in tertiary education, these students are less likely to enrol in a second year of tertiary study, or complete their degree. In line with our tertiary education findings, we do not find evidence to suggest the increase in tertiary education uptake or low ability students increases wages five years after leaving high school. However, the absence of data on long-term economic outcomes and the rapidly changing labour market conditions following the disaster challenge a full account of how the disaster's effects on education translate into changes in economic circumstances.

Our result stands in contrast with much of the research on disaster and education attainment in developing countries, which find largely negative effects on education (Spencer, Polachek, and Strobl (2016), and Cas et al. (2014)). One reason for this disparity could be that households in developing countries lose a greater proportion of income in a disaster, forcing students to seek employment instead of pursuing education. This hypothesis is supported by McDermott, Barry, and Tol (2014), who find that access to credit can help prevent school drop-out.

There are three possible channels that may explain the positive effects on the demand for university. Firstly, as discussed by Deryugina, Kawano, and Levitt (2018) and Sacerdote (2012), poor local labour market conditions following a disaster may reduce the opportunity cost of further education and increase tertiary enrolment. However, while overall employment declines in the region following the earthquake, the disaster causes an increase in demand for construction, a sector which disproportionately employs relatively low ability students. If the effects are driven by reduced local labour market opportunities, we would expect to find a negative effect on enrolment for this group. On the contrary, we find low ability students see the greatest magnitude increases in tertiary enrolment.

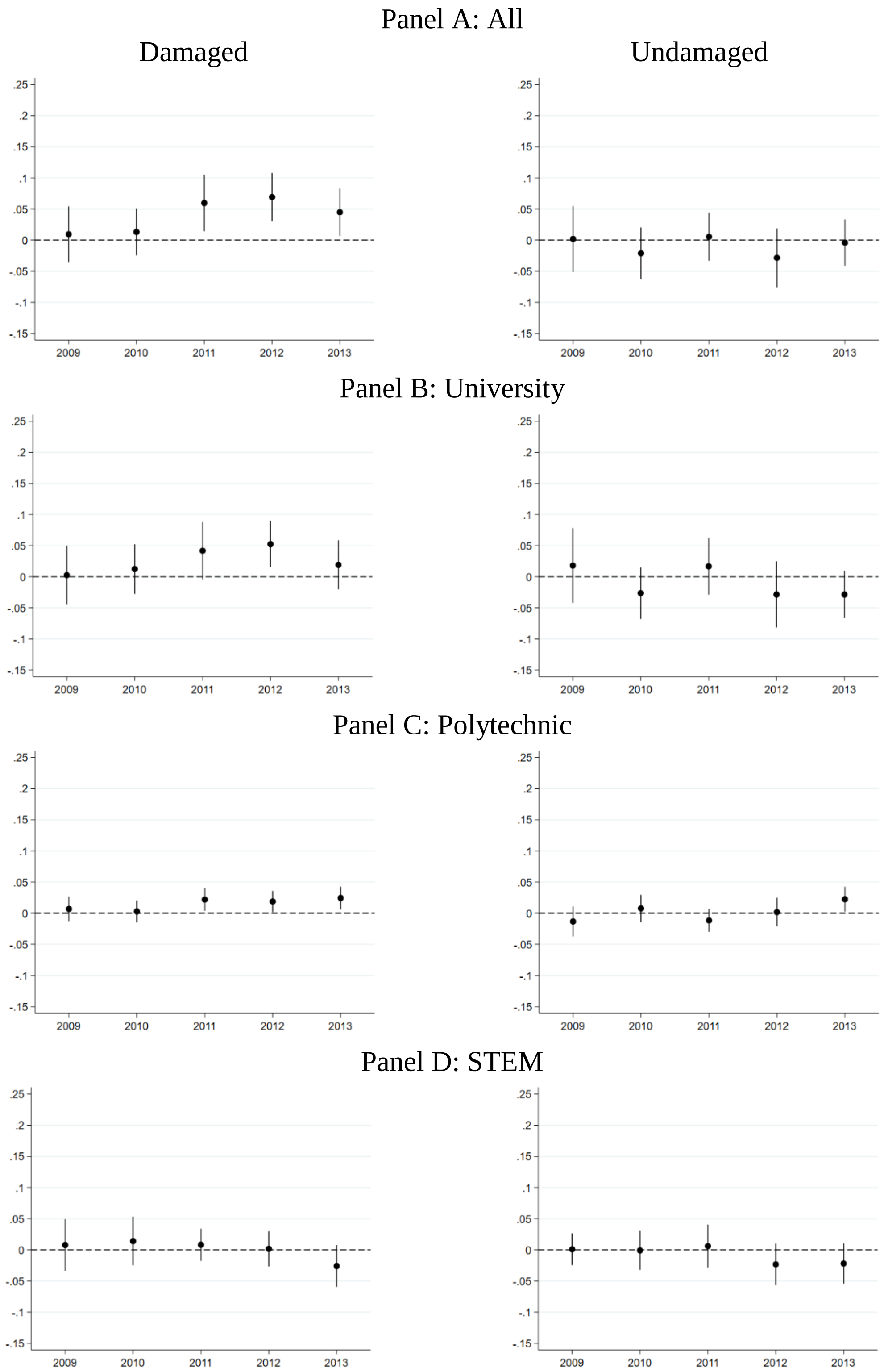
Secondly, the increase in tertiary enrolment may be due to behavioural changes. Experiencing a disaster may trigger a re-evaluation of values and long-term goals, effectively reducing people's discount rates. This conclusion is consistent with Callen (2015) who finds that two years after the 2004 Indian Ocean Earthquake, survivors exhibit significantly greater patience. Callen finds that effects are largest for individuals with the lowest academic achievement and lowest cognitive test performance. A lower discount rate is linked to higher educational attainment (Castillo et al. (2011), Golsteyn, Grönqvist, and Lindahl (2014), Cadena and Keys (2015)), suggesting that changed time preference due to the disaster may positively affect university enrolment.

Finally, the increase in enrolment may be driven by local recovery efforts attempting to mitigate the harm done to survivors. In Christchurch, students benefited from grade adjustment and greater leniency when applying to university. Initiatives were taken to encourage high school graduates to enrol in university. For example, the University of Canterbury and alumni groups allocated funding to support affected high school students by covering tuition fees for their first year of university, with the aim of lessening expected declines in local university enrolment.[12] The university also expanded an after-school homework club for selected schools in low socio-economic areas that were damaged by the earthquake. These attempts to strengthen the links between local schools and the university following the disaster represent an aspect of treatment, and may demonstrate that a timely policy response can be highly influential for students. However, we assume that policy makers intend for those who enrol in university to also complete a degree, and we find no evidence to support this outcome. While we cannot say that students who drop out of university would be better off had they never

[12] From 2012 a new scholarship for the first year of undergraduate study at the University of Canterbury was introduced for students from selected local schools. This scholarship was awarded to 20 students in 2012, and 8 in 2013. In 2012, back-of-the-envelope calculations suggest that approximately 90 students from damaged schools attended university due to the earthquake (6% of 1,490). The scholarship can therefore only explain a fifth of the effect we estimate. The university also offered 95 scholarships worth US$1,400 (2019 dollars) to returning local students in 2012, to prevent drop-out due to financial hardship.

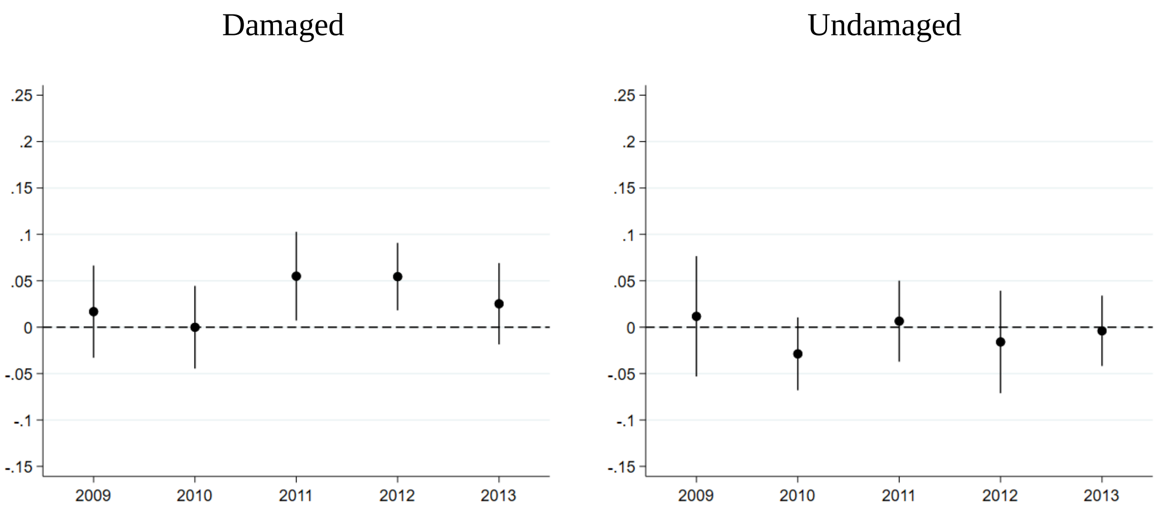
enrolled, our results suggest there may be more efficient and targeted ways of helping recent high school graduates cope in the wake of a disaster.

Figure 2.1. Dynamic impact of earthquake on tertiary enrolment: School heterogeneity



Notes: These figures plot point estimates of the effects of being a high school senior from damaged and undamaged schools in the Canterbury region during the 2011 earthquake using the specification in equation (2.2). The indicators for damage level are defined in Table 2.1. The sample is 134,559 high school seniors 2008 – 2013. The outcome for each panel is an indicator equal to 1 if, within two years after a student's senior year, the student (A) enrols in tertiary education; (B) enrols in university; (C) enrols in a polytechnic; (D) enrols in a STEM degree. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

Figure 2.2. Dynamic impact of earthquake on tertiary enrolment within one year

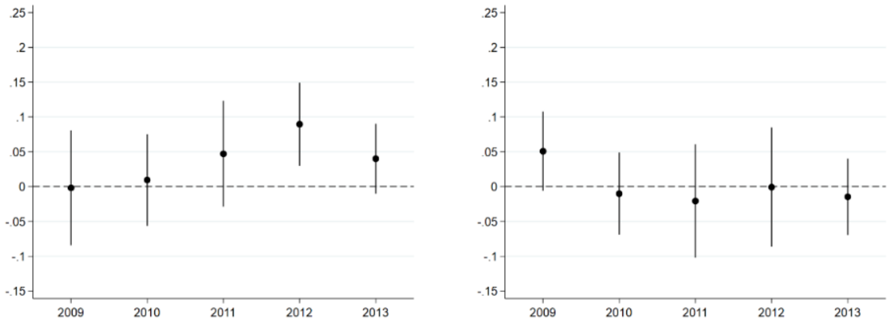


Notes: These figures plot point estimates of the effects of being a high school senior from damaged and undamaged schools in the Canterbury region during the 2011 earthquake using the specification in equation (2.2). The indicators for damage level are defined in Table 2.1. The sample is 134,559 high school seniors 2008 – 2013. The outcome is an indicator equal to 1 if, within one years after a student's senior year, the student enrols in tertiary education. Robust standard errors account for clustering by high school. The regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

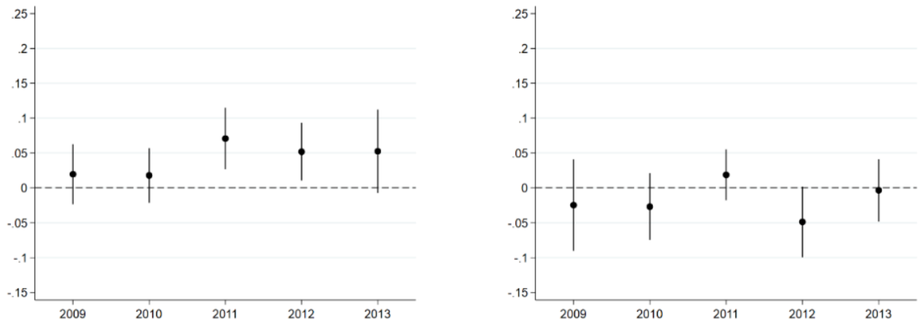
Figure 2.3. Dynamic impact of earthquake on tertiary enrolment: Stratified sample

Panel A: Men

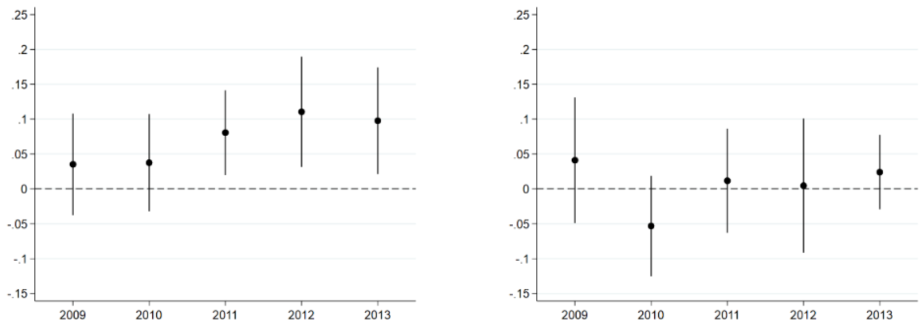
Damaged | Undamaged



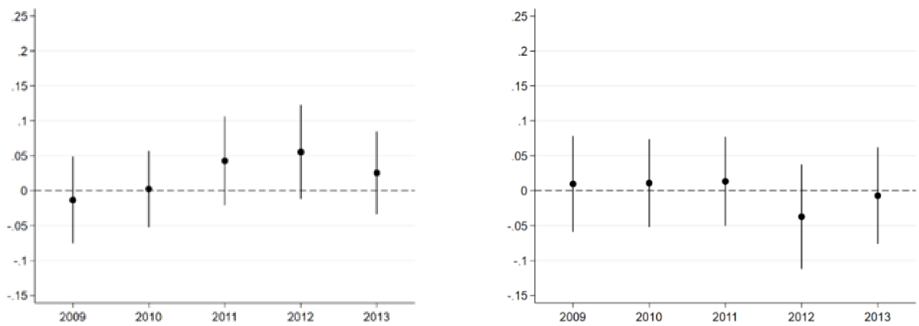
Panel B: Women



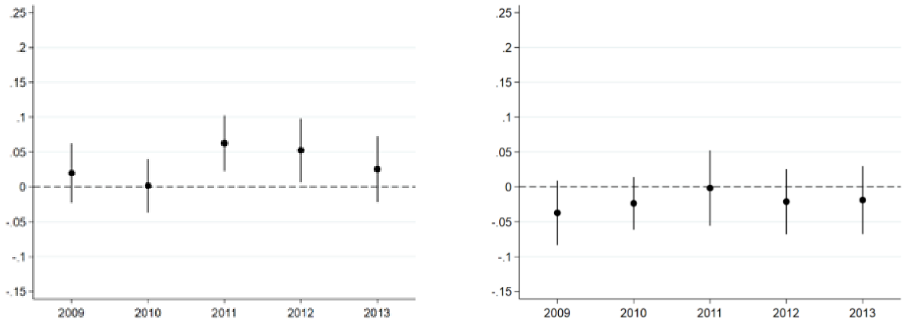
Panel C: Low relative ability



Panel D: Medium relative ability

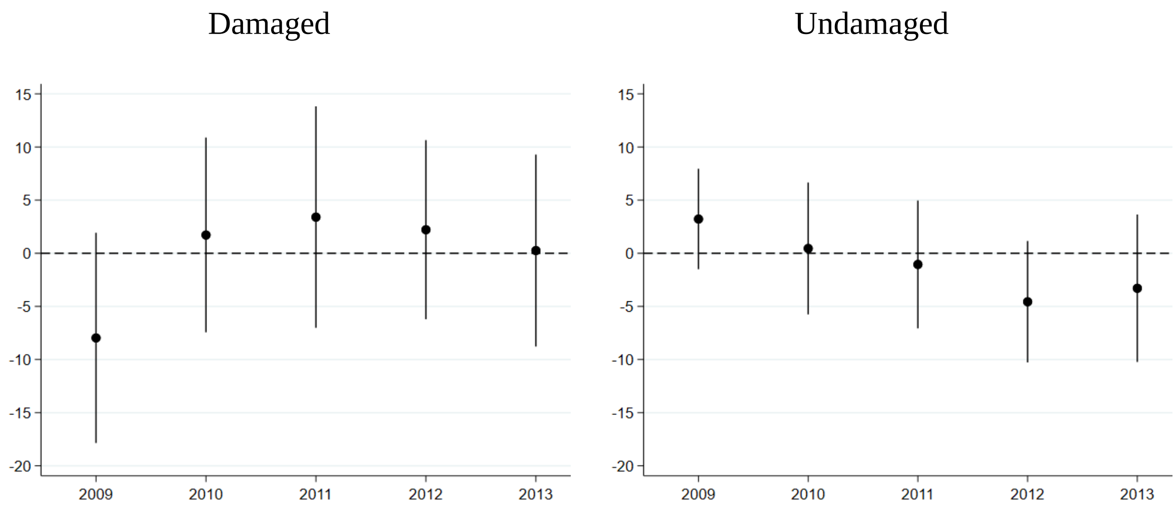


Panel E: High relative ability



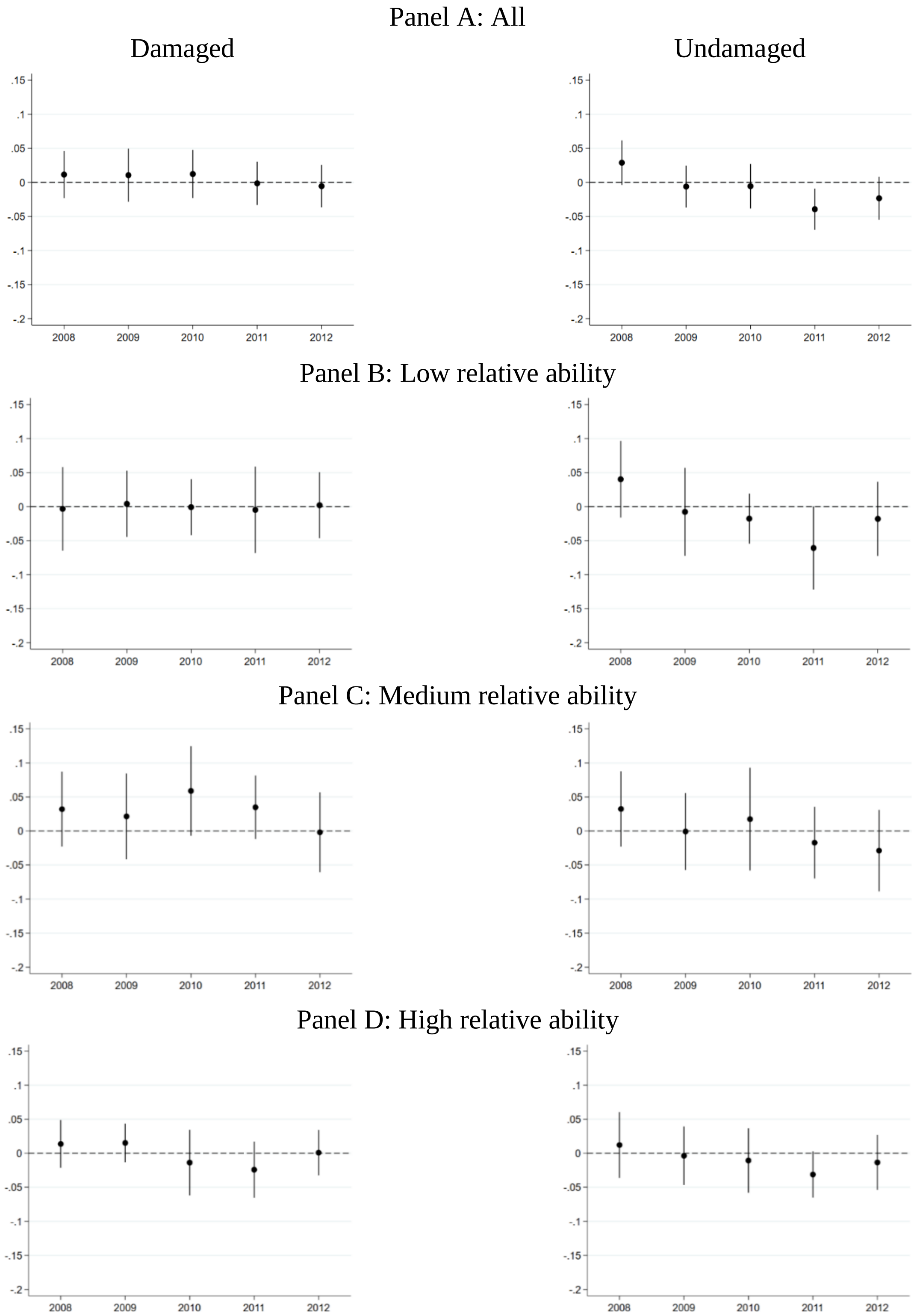
Notes: These figures plot point estimates of the effects of being a high school senior from damaged and undamaged schools in the Canterbury region during the 2011 earthquake using the specification in equation (2.2), stratified by gender and ability. The indicators for damage level are defined in Table 2.1. The outcome for each panel is an indicator equal to 1 if, within two years after a student's senior year, the student enrols in tertiary education. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

Figure 2.4. Impact of earthquake on number of students enrolled as high school seniors



Notes: These are estimates from equation (2.3) using a sample of six cohorts of high school seniors, aggregated by school and cohort. The sample is 2,337 schools by year. The outcome variable is the number of students in school cohort. Damage is measured by level of damage sustained by school attended, summarised in Table 2.1. Robust standard errors clustered by school are in parentheses. Each regression also includes cohort and school fixed effects, and controls for gender and ethnicity.

Figure 2.5. Impact of earthquake on junior high school enrolment the following year

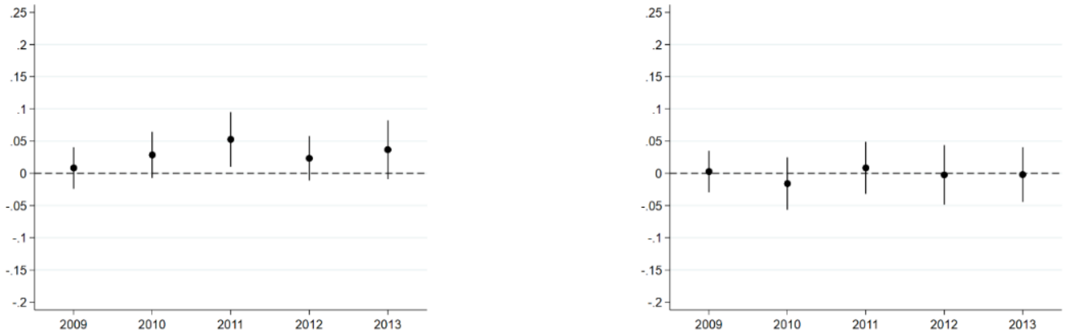


Notes: Point estimates of the effects of being a high school junior in damaged and undamaged schools in the Canterbury region during the 2011 earthquake using equation (2.2). The total sample for Panel A is 225,942 high school juniors in cohorts 2007 – 2012. The indicators for damage level are defined in Table 2.1. The outcome for each panel is an indicator equal to 1 if, the student enrols as a senior the following year. Panels B – D show estimates when the sample is stratified by relative ability. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

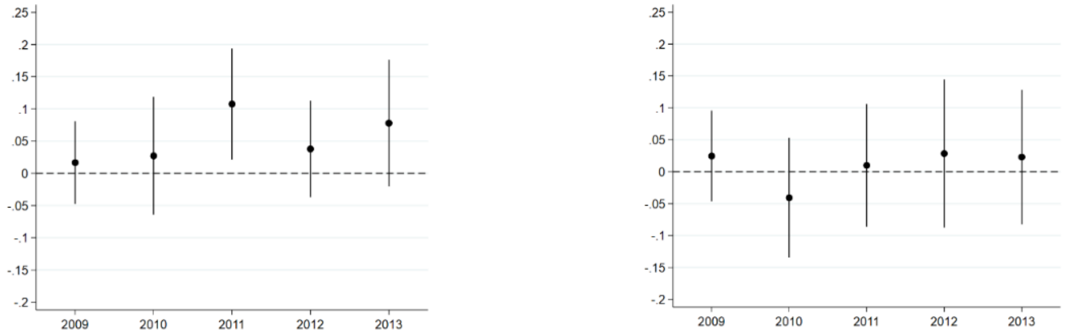
Figure 2.6. Impact of earthquake on University Entrance qualification achievement

Panel A: All

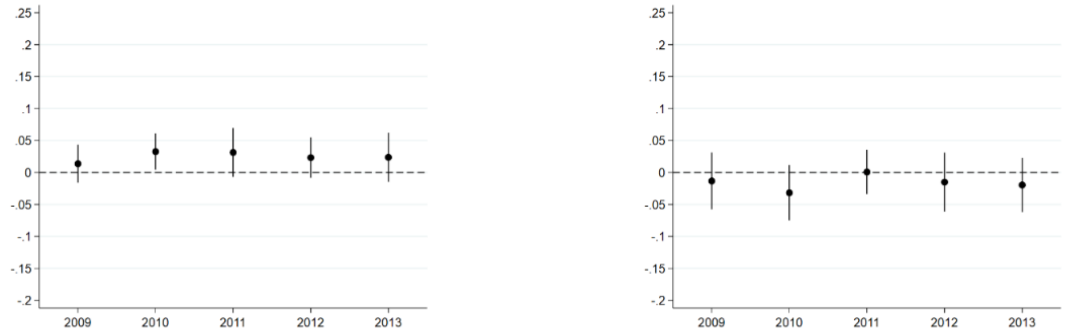
Damaged | Undamaged



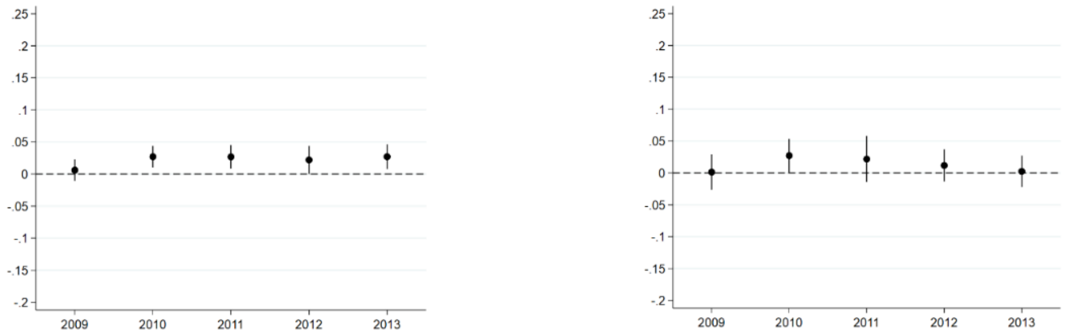
Panel B: Low relative ability



Panel C: Medium relative ability

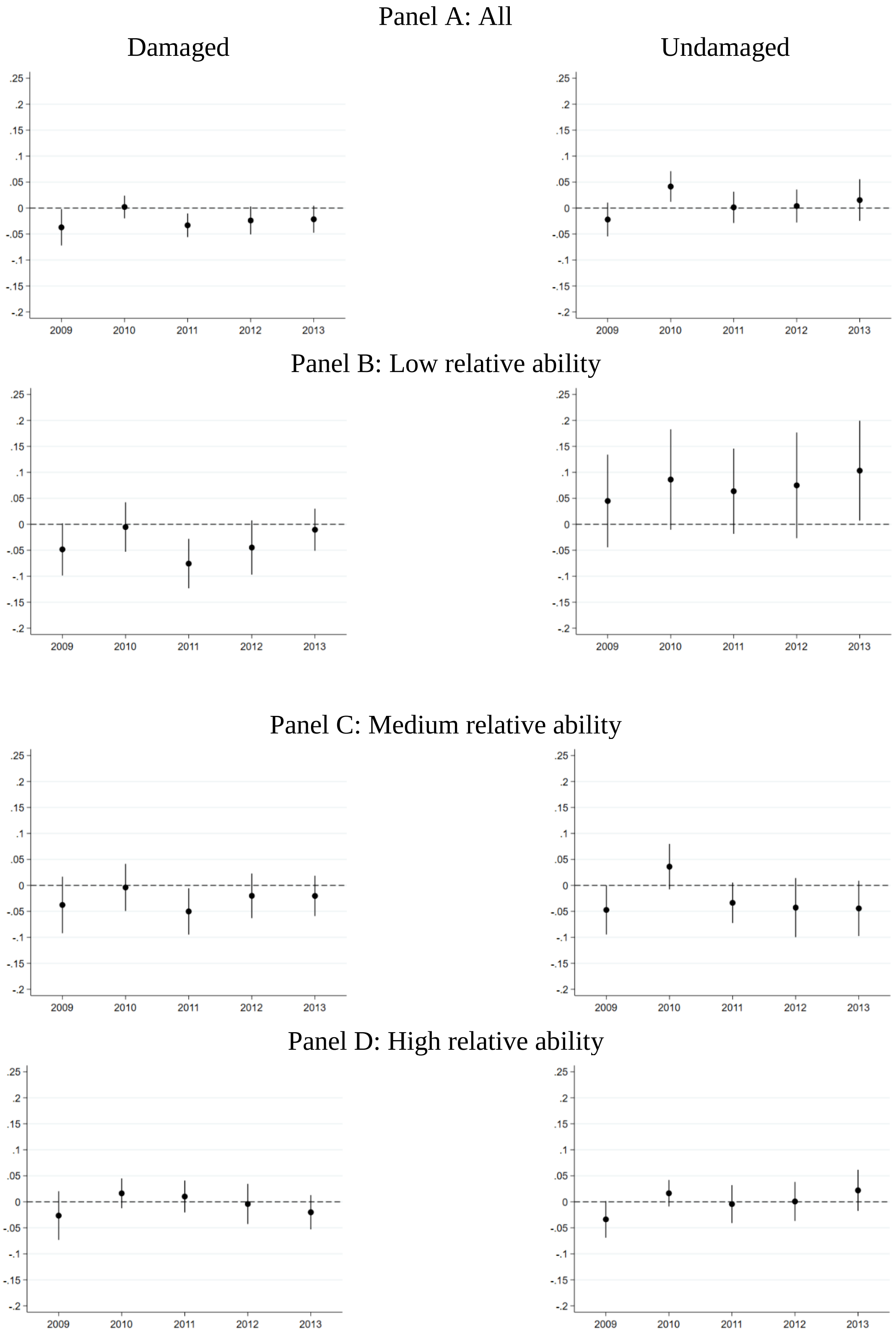


Panel D: High relative ability



Notes: These figures plot point estimates of the effects of being a high school senior in damaged and undamaged schools in the Canterbury region during the 2011 earthquake using the specification in equation (2.2). The total sample for Panel A is 134,559 high school seniors 2008 – 2013. The outcome for each panel is an indicator equal to 1 if the high school senior achieves the university entrance qualification. The indicators for damage level are defined in Table 2.1. Panels B – D show estimates when the sample is stratified by relative ability. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

Figure 2.7. Re-enrolment in second year of tertiary education

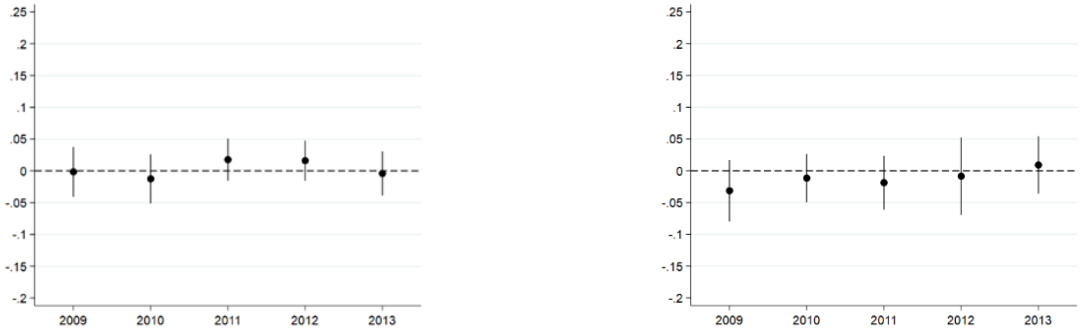


Notes: These figures plot point estimates using equation (2.2) using a sample of six cohorts of senior students who enrol in tertiary education within two years post high school. The outcome is an indicator equal to 1 if the high school student enrols in a second year of tertiary education. The indicators for damage level are defined in Table 2.1. Panel A includes all 97,674 students. Panels B – D show estimates when the sample is stratified by relative ability. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

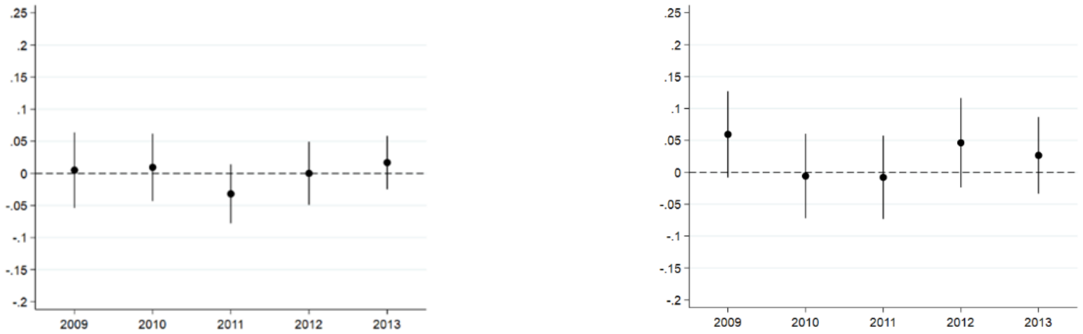
Figure 2.8. Degree completion within four years post-high school

Panel A: All

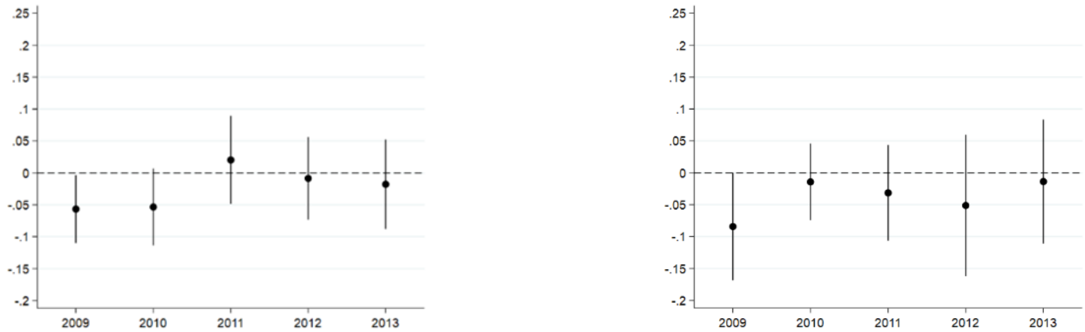
Damaged Undamaged



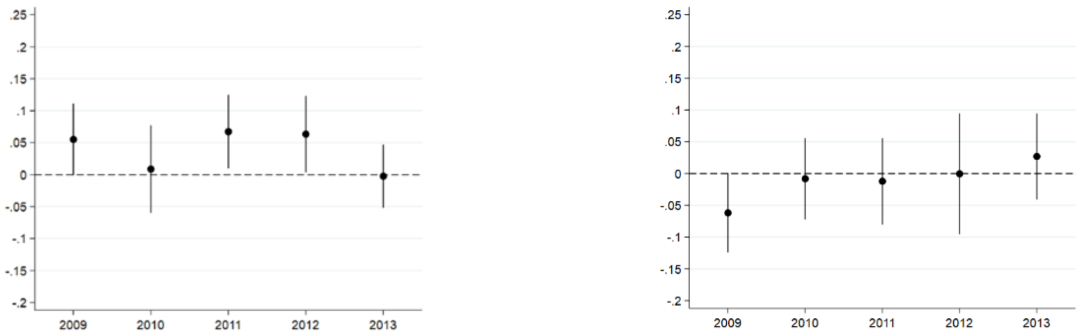
Panel B: Low relative ability



Panel C: Medium relative ability



Panel D: High relative ability

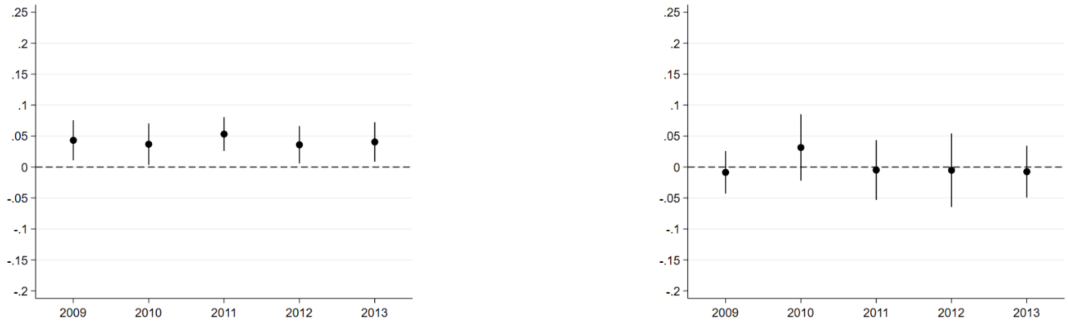


Notes: These figures plot point estimates using a sample of 134,559 high school seniors, where the outcome is an indicator equal to 1 if the high school student has completed a tertiary degree within four years of leaving high school. The indicators for damage level are defined in Table 2.1. Panels B – D show estimates when the sample is stratified by relative ability. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

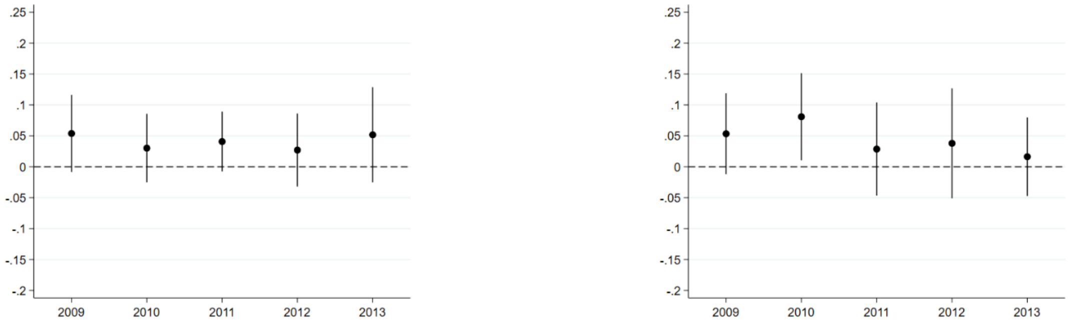
Figure 2.9. Top 50th percentile tertiary educated job industry five years later

Panel A: All

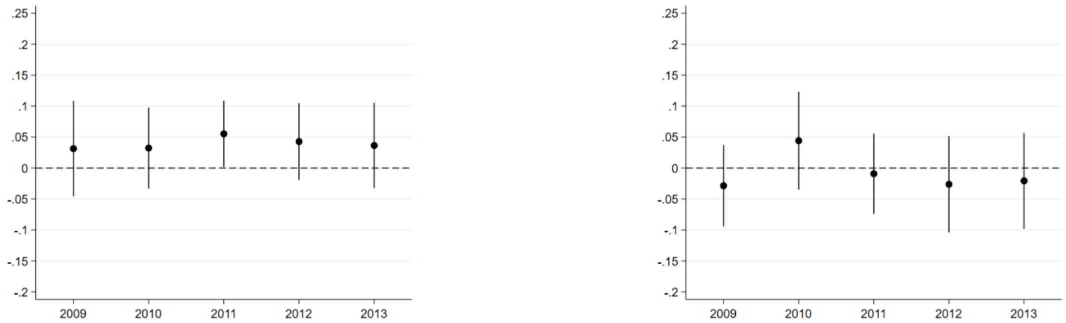
Damaged | Undamaged



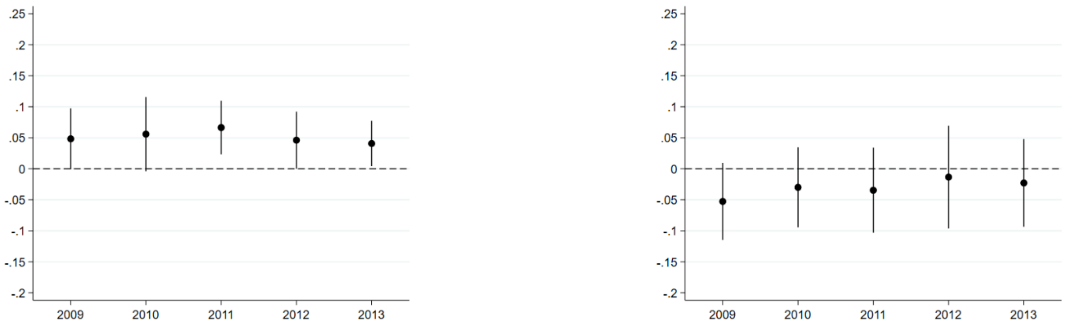
Panel B: Low relative ability



Panel C: Medium relative ability



Panel D: High relative ability



Notes: These figures plot point estimates using a sample of 134,559 high school seniors, where the outcome is an indicator equal to 1 if the high school student is employed in an industry associated with having a degree. The indicators for damage level are defined in Table 2.1. Panels B – D show estimates when the sample is stratified by relative ability. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. 95 percent confidence intervals are shown for each point estimate.

Table 2.1. Students' high school exposure level definitions

Non-Canterbury Schools	Canterbury – Undamaged Area Schools	Canterbury – Damaged Area Schools
Criteria: 1) Student is a high school senior in 2011 or later, and does not attend a Canterbury high school at the time of the 2011 Christchurch Earthquake, or 2) Student is a high school senior in 2010 or earlier, and while a senior, does not attend a Canterbury high school.	Criteria: 1) Student is a high school senior in 2011 or later, and attends a Canterbury high school in an ***undamaged*** area at the time of the 2011 earthquake, or 2) Student is a high school senior in 2010 or earlier, and while a senior, attends a Canterbury high school located in an area ***undamaged*** by the 2011 earthquake.	Criteria: 1) Student is a high school senior in 2011 or later, and attends a Canterbury high school in a ***damaged*** area at the time of the 2011 earthquake, or 2) Student is a high school senior in 2010 or earlier, and while a senior, attends a Canterbury high school located in an area ***damaged*** by the 2011 earthquake.

Table 2.2. Summary statistics for high school seniors 2008 – 2013

	All	Non-Canterbury	Canterbury - Undamaged Area Schools	Canterbury – Damaged Area Schools
N	134,559	118,125	7,491	8,940
Percent	100	87.77	5.56	6.64
Female	0.581	0.582	0.626	0.53
	(0.493)	(0.493)	(0.484)	(0.499)
Age	17.7	17.7	17.7	17.7
	(0.5)	(0.5)	(0.5)	(0.5)
Ethnicity				
European	0.737	0.723	0.895	0.785
	(0.440)	(0.447)	(0.307)	(0.411)
Indigenous (Māori)	0.127	0.135	0.072	0.071
	(0.333)	(0.342)	(0.258)	(0.257)
Pacific Islander	0.078	0.086	0.019	0.025
	(0.268)	(0.280)	(0.135)	(0.156)
Asian	0.165	0.170	0.065	0.179
	(0.371)	(0.376)	(0.246)	(0.383)
Middle East/ Latin America/Africa	0.031	0.031	0.024	0.032
	(0.173)	(0.174)	(0.153)	(0.175)
Other	0.012	0.012	0.017	0.015
	(0.109)	(0.107)	(0.128)	(0.120)
Matched to wages 5 years later	0.82	0.82	0.85	0.82
	(0.38)	(0.39)	(0.35)	(0.39)
Average monthly wages 5 years later	1406.94	1401.05	1537.34	1375.45
	(1107.57)	(1107.48)	(1081.86)	(1123.09)
Average number of NCEA 3 standards	26.6	26.7	25.4	26.1
	(6.4)	(6.4)	(7.0)	(5.7)
NCEA 3 standards merit or excellence	0.30	0.30	0.28	0.33
	(0.21)	(0.21)	(0.21)	(0.22)
Tertiary enrolment within two years	0.726	0.728	0.671	0.745
	(0.446)	(0.445)	(0.470)	(0.436)
Number of schools	417	367	34	16

Notes: In line with data use requirements by Statistics New Zealand, counts are randomly rounded to a number divisible by three.

Table 2.3. Impact of earthquake on tertiary enrolment

N = 134,559	(1) Any Tertiary	(2) University	(3) Polytechnic	(4) STEM
Panel A. Pooled Effect				
Canterbury × Post	0.0265**	0.0130	0.0130***	-0.0131
	(0.0111)	(0.0090)	(0.0047)	(0.0092)
Canterbury schools' 2008-2010 cohorts mean	0.716	0.640	0.073	0.234
Panel B. School Damage Heterogeneity				
Damaged × Post	0.0502***	0.0324***	0.0185***	-0.0130
	(0.0135)	(0.0096)	(0.0059)	(0.0129)
Undamaged × Post	-0.0019	-0.0104	0.0063	-0.0132
	(0.0112)	(0.0105)	(0.0063)	(0.0122)
Damaged schools' 2008-2010 cohorts mean	0.739	0.672	0.063	0.258
Undamaged schools' 2008-2010 cohorts mean	0.689	0.602	0.085	0.206

Notes: Panel A shows results from equation (2.1) where damage categories are pooled. Panel B shows results from equation (22). The outcome for each column is an indicator equal to 1 if, within two years after a student's senior year, the student (1) enrols in tertiary education; (2) enrols in university; (3) enrols in a polytechnic; (4) enrols in a STEM degree. Post equals 1 for 2011 and later cohorts, and 0 otherwise. The dummy variable Canterbury equals one for students from Damaged and Undamaged schools, as defined in Table 2.1. Robust standard errors account for clustering by high school. Each regression includes cohort and school fixed effects, and controls for gender and ethnicity. The mean of each column's outcome variable for the 2008-2010 Canterbury cohorts is reported at the bottom of each panel.

Table 2.4. Impact of earthquake on achieving NCEA Levels 1-3

N = 563,064	(1) NCEA1	(2) NCEA2	(2) NCEA3
Canterbury*1[Birth year = 1990]	.	.	.
	.	.	.
Canterbury*1[Birth year = 1991]	-0.00492	-0.00806	-0.00685
	(0.00777)	(0.00806)	(0.00764)
Canterbury*1[Birth year = 1992]	-0.00774	-0.00969	-0.00298
	(0.00767)	(0.00791)	(0.00758)
Canterbury*1[Birth year = 1993]	0.00301	-0.000460	0.00509
	(0.00756)	(0.00782)	(0.00752)
Canterbury*1[Birth year = 1994]	0.00576	-0.00180	-0.00324
	(0.00758)	(0.00780)	(0.00749)
Canterbury*1[Birth year = 1995]	-0.00546	-0.00953	-0.00636
	(0.00749)	(0.00771)	(0.00744)
Canterbury*1[Birth year = 1996]	-0.0142*	-0.00588	-0.00888
	(0.00748)	(0.00769)	(0.00741)
Non-Canterbury mean [1990]	0.54	0.45	0.27
	(0.50)	(0.49)	(0.44)

Notes: Interactions between having an address in the Canterbury region at age 14 and birth cohort. Column (1) outcome is an indicator for achieving NCEA 1 by age 17. Column (2) outcome is an indicator for achieving NCEA 2 by age 18. Column (3) is an indicator for achieving NCEA 3 by age 19. Also includes controls for region of birth, sex and ethnicity. Robust standard errors.

Table 2.5. Impact of earthquake on tertiary enrolment, by region

N = 134,559	(1) Canterbury	(2) Auckland	(3) Wellington	(4) Other
Damaged × Post	-0.0263	0.0210***	0.0289***	0.0266***
	(0.0194)	(0.00726)	(0.00763)	(0.00920)
Undamaged × Post	-0.0455***	0.00372	0.0120**	0.0278**
	(0.0126)	(0.00527)	(0.00571)	(0.0126)
Damaged schools' 2008-2010 cohorts mean	0.524	0.033	0.045	0.137
Undamaged schools' 2008-2010 cohorts mean	0.455	0.017	0.044	0.172

Notes: These are estimates from equation (2.1), using a sample of six cohorts of senior students 2008 - 2013. The outcome variable is an indicator equal to 1 if the student, within two years post high school graduation, enrols in tertiary education in (1) the Canterbury region; (2) the Auckland region; (3) the Wellington region; (4) other regions. Exposure is measured by level of damage sustained by school attended, summarised in Table 2.1. Robust standard errors clustered by school are in parentheses. Each regression also includes cohort and school fixed effects, and controls for gender and ethnicity.

Table 2.6. Average monthly earnings five years after leaving school

		Relative high school ability		
	(1) All	(2) Low	(3) Medium	(4) High
Damaged × 2009	7.146	1.801	39.29	-17.22
	(56.18)	(89.39)	(65.92)	(76.00)
Damaged × 2010	32.47	70.75	57.60	-16.94
	(45.84)	(67.24)	(61.81)	(66.83)
Damaged × 2011	79.50	110.0	132.1***	-4.300
	(56.06)	(116.3)	(46.71)	(68.36)
Damaged × 2012	-6.112	-19.11	63.26	-54.53
	(53.77)	(118.7)	(57.55)	(60.76)
Damaged × 2013	-20.53	-36.96	-1.217	-8.533
	(33.58)	(83.87)	(46.82)	(66.39)
Undamaged × 2009	-18.22	124.8	-54.23	-118.7*
	(37.28)	(78.38)	(75.36)	(64.89)
Undamaged × 2010	38.48	167.5***	45.93	-85.76*
	(26.54)	(51.75)	(64.82)	(51.13)
Undamaged × 2011	-9.351	54.89	22.03	-115.3
	(39.37)	(53.28)	(76.52)	(76.51)
Undamaged × 2012	-22.19	27.47	-48.21	-36.64
	(42.54)	(56.36)	(70.81)	(66.63)
Undamaged × 2013	-28.47	24.66	-11.40	-96.06
	(36.09)	(65.23)	(76.48)	(74.02)
2008 Damaged mean	1207.17	1319.26	1188.92	1091.32
2008 Undamaged mean	1421.69	1443.79	1430.83	1368.06
N	134,559	43,749	44,853	44,058

Notes: These are estimates from equation (2.2), on a sample of six cohorts of high school seniors. The outcome variable is average monthly earnings, five years after high school graduation. Exposure is measured by level of damage sustained by school attended, summarised in Table 2.1. In columns 2 – 4 the sample is stratified by relative ability. Robust standard errors clustered by school are in parentheses. Each regression also includes cohort and school fixed effects, and controls for gender and ethnicity.

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3 REPEAT DISASTER EXPOSURE AND STUDENT OUTCOMES

Introduction

Natural disasters are a major threat to the global population. Between 1994 and 2013, on average almost 68,000 lives were lost per year due to natural disasters, with a further 218 million people affected (UNISDR 2015). Due to the impact of disasters on mental health, and concern that trauma exposure will hinder academic performance and reduce resilience to future shocks, many schools and universities in disaster-prone developed countries offer counselling support in the wake of a disaster. Following Christchurch earthquake in 2011, residents with high levels of exposure had 1.4 times higher rates of mental disorder compared to those not exposed, driven by increases in major depression, PTSD, anxiety disorders and nicotine dependence (Fergusson et al. 2014). One aim of a city-wide wellbeing campaign following the earthquake was to promote psychological resilience to future shocks (Calder et al. 2016). However, we know little about the education implications of compound trauma: does previous disaster exposure affect student outcomes following a new shock?

In this paper, we examine how previous exposure to an earthquake affects university student outcomes when they experience an additional earthquake, compared to those with no previous earthquake exposure. A history of prior trauma is a significant predictor of PTSD onset in the wake of a disaster (Galea, Nandi, and Vlahov 2005). Thus, one might presume that prior disaster exposure would be harmful to academic performance following additional shock. Yet, at the same time, it is commonly observed that disaster exposure can build resilience to future shocks, suggesting that prior experience may increase psychological resilience for the majority (Bonanno et al. 2010). Thus, the impact of prior disaster exposure on student outcomes in the wake of further disaster is ambiguous.

To address this question, we turn to Victoria University of Wellington (VUW), where all students were subject to an earthquake in 2013. A key advantage of this university for our analysis is that data available contains information on school attended prior to university, which can be used as an indicator of previous disaster experience. We use the plausibly exogenous variation in exposure to an earthquake in 2011, which only affected students at VUW who attended school in the Canterbury region, and retrieve the causal effect of subsequent exposure to natural disaster on academic performance, using the 2013 earthquakes which affected all students at VUW. Our research design attempts to adopt the desirable properties of a randomised controlled experiment. In the ideal experiment, a disaster would strike a university, at which a random half of the students have never experienced disaster before (the "control" group), and the other half have experienced a disaster before (the "treatment" group). We are interested in the difference in the impact on grades for students in the treatment group, compared to students in the control group, when all are affected by disaster at university.

We find that the 2013 earthquake has no different impact for students with prior earthquake exposure, compared to those without. We show that this result is not a product of the change in composition of students who choose to attend university following an earthquake. Overall, our findings suggest that previous experience of earthquakes is not predictive of response to an additional shock two years later.

Background

Earthquakes in New Zealand

New Zealand has been subject to numerous large earthquakes over the past ten years. In September 2010, a large earthquake of magnitude 7.1 occurred in Canterbury, causing severe structural damage but few casualties. This earthquake was followed by several major aftershocks in the subsequent months, including a severely destructive tremor of magnitude 6.3 centred near the city of Christchurch in February 2011. Further shocks that were part of the same earthquake sequence affected the region, most notably in June and December 2011, May 2012 and February 2016. Overall, Parker and Steenkamp (2012) estimate the total economic cost of the sequence to be NZ$30 billion.

The February 2011 Christchurch earthquake was amongst the deadliest in New Zealand's history, killing 185 people and injuring thousands more. The tremor affected over 150,000 houses, and a residential "red zone" deemed not fit for repair included over 7,500 houses. Long term effects included the closure of several schools and complications with insurance, leaving many households in an unknown financial situation for years after the event. Fully subsidised counselling was offered to those in affected areas due to the risk of PTSD, and concern that traumatic exposure may reduce resilience to future shocks.

In 2013, a pair of large earthquakes occurred off the coast, between the North and South Islands of New Zealand. The first struck on 21 July with a magnitude of 6.5, and was felt on both Islands. The earthquakes caused NZ$30 million of insured damage (EQC 2013). In the Wellington region, parts of the CBD were closed for assessment of damaged buildings, and train services were stopped. At the university, all campuses were closed for a day for structural assessment. The Law school sustained significant damage and was closed for one week. The Commerce Faculty rescheduled disrupted classes to take place in the first week of the study break before exams, and arranged to delay October exams by one week. On 16 August, a second earthquake of magnitude 6.6 occurred in the same area. This earthquake caused further damage, and all VUW campuses were closed for three days. Students were instructed to submit assignments via email if possible, and course coordinators were advised to consider the impact of the earthquake on a case-by-case basis when grading work submitted.

The 2013 earthquakes occurred in the middle of Trimester 2 study and affected all students at VUW at the time, while the 2011 earthquake was only felt by the students at VUW who attended high school in Canterbury. We use this natural variation in earthquake exposure to identify the impact of previous disaster experience on grades following subsequent disaster.

Disaster and student performance

Disasters can affect student performance through several mechanisms. A primary impact comes from disruption to university infrastructure. Direct injury, lost teaching days, damaged buildings and disrupted transport networks affect both students and teachers. A secondary impact comes from financial insecurity through building damage or unemployment, relocation, loss or injury of family members, and personal mental health (Dahl and Lochner (2012) and Heinlein and Shinn (2000)).

Several studies observe that shocks are associated with decreased academic performance and other adverse student outcomes. Existing research mostly focuses on children and adolescents. Holmes (2002) finds that extreme storms in North Caroline have a negative impact on the test scores of elementary school students. Ceyhan and Ceyhan (2007) investigate the quality of life and academic achievement of survivors six years after earthquakes in Turkey, and find academic achievement of those with earthquake exposure is significantly lower than those that have not experienced the earthquake. An analysis of the impact of an earthquake in Italy finds that experiencing the earthquake increases the probability that women do not graduate on time (Pietro 2015).

Disaster and mental health

There is well documented evidence of the mid to long-term impact of disaster on mental health. In a small study, Reijneveld et al (2003) find that exposure to disaster during adolescence is associated with anxiety and depression five months later. Yule et al (2000) investigate the long-term psychological effects of a shipping disaster experienced during adolescence, and find that half of the survivors developed PTSD following the event, and a third of these still suffered 5-8 years later.

However, there is mixed evidence for the impact of repeated disaster exposure. The "sensitisation hypothesis" suggests that repeated trauma exposure increases the likelihood of a pathological response (Peretz et al. 1994). Recurring exposure may accumulate, wearing down resistance. Consequently, earthquakes affecting students with prior earthquake exposure have the potential to significantly affect their pathological response, with implications for their academic performance. Furthermore, recovery from trauma is aided by close community and family links, and students attending university in a city away from home may have fewer support networks. Therefore, students at VUW who come from Canterbury may be particularly susceptible to impacts from new shocks.

Several studies suggest that repeated exposure to disaster is associated with a more substantial impact of new trauma (Regehr et al. (2007), Stephens, Long, and Miller (1997), Andersen et al. (2013)). Udwin et al (2000) examine risk factors for the development of PTSD following trauma, finding that the severity and duration of the condition is best predicted by pre-disaster vulnerability factors of social, physical, and psychological difficulties. Dougall et al (2000) examine the impact of prior trauma exposure on psychological response to an airline disaster, and find that experience of a variety of different traumatic experiences sensitises workers to a new stressor, but experience of similar trauma is not a predictor of chronic stress.

At the same time, there is evidence for the "inoculation hypothesis", which posits that prior trauma exposure may be protective of future trauma. As a result, exposure to an additional earthquake may not be so harmful for students with previous earthquake experience. Norris and Murrell (1988) find modest flood effects on trait anxiety in older adults without prior flood experience, but no flood effects in older adults who have been in floods before. Despite well documented evidence of the impact of disaster on student performance, and repeat trauma on mental health, to our knowledge no studies examine the role of prior disaster exposure on academic outcomes in the wake of a repeat event.

Data

We use administrative data from VUW which records courses taken by each student each year. This dataset is at individual by course level, and contains grade achieved, trimester, and year the course was taken. We can track students throughout their years enrolled at VUW. In addition, we use the following demographic variables; year of study, age, sex, ethnicity, year of leaving school and school region. The focus of our study is students with prior earthquake exposure. We identify these students as those who graduate from high school in the Canterbury region[13].

Our final sample includes students who are enrolled at VUW between 2008 and 2016[14], aged 17-20 when they first enrol, who are working towards an undergraduate degree, and are domestic students. The means for our sample are presented in Table 3.1. 5.7 percent of students attend high school in Canterbury, and 44.2 percent attend high school in Wellington. Half of all courses are taken in Trimester 2. Students from Canterbury are significantly more likely to achieve A and B grades, less likely to be Māori, and more likely to be female, compared to students not from Canterbury (p < 0.01).

Empirical strategy

Firstly, we investigate the impact of the 2013 earthquakes on all students. We then turn to our research question of interest; is the impact of the 2013 earthquake on grades different for students with previous earthquake experience?

To identify the impact of the 2013 earthquake on all students, we use a difference-in-differences model. We compare student grades in Trimester Two in 2013 when the earthquake occurred with grades in Trimester One of the same year, and with Trimester Two performance in other years. We run a regression of the form

(3.1)

$$GRADE_{ict} = \beta_1 + \beta_2 T2_t + \beta_3 Yr2013_t + \beta_4 T2_t \times Yr2013_t + X_s + \delta_{iy} + \varepsilon_{ict}$$

$GRADE$ is our measure of outcome, which is a standardised form of a discrete variable taking a value from 0 to 9, and is observed at the course level (c). Each number represents the grade achieved for each course a student takes each year, which can range from D to A+. We include fixed effects for each individual by year (δ_{iy}) and each subject (X_s). Individual-by-year fixed effects means we are constraining our attention to compare Trimester 1 and Trimester 2

[13] This is an imperfect measure of disaster experience, because not all students who attended high school in Canterbury will have been present during the earthquakes, and some students who did not attend high school in Canterbury will have been present.
[14] On 14 November 2016, a major earthquake affected students in Wellington. However, the exam period finished on 13 November, so this will not have affected students in our sample.

performance within individual, within year. By observing only variation within person within year, we are not concerned about different abilities between students, and different course difficulty between years. We compare the gap between Trimester 1 and Trimester 2 performance across years, and investigate if this gap is particularly large or small in 2013, the year of the earthquakes which affected VUW. We attribute any difference in the gap, relative to other years, to the effects of the earthquakes on the sample of all students. In equation (3.1), the parameter of interest is the interaction between Trimester 2 ($T2$) and a dummy variable for when the year is 2013 ($Yr2013$).

This estimation strategy in equation (3.1) relies on the assumption that the gap in Trimester 1 and Trimester 2 performance only changes because of the effects of the earthquakes. However, it fails to account for possible compositional changes in the student body which could bias estimates of the causal effect. If, for example, there are more out-of-town students in 2013, and these students on average do better in Trimester 2 than Trimester 1, then we would be spuriously attributing this change to the earthquakes.

(3.2)

$$GRADE_{cit} = \beta_1 + \beta_2 Canterbury_i + \beta_3 T2_t + \beta_4 Yr2013_t + \beta_5\, T2_t \times Yr2013_t + \beta_6 Canterbury_i \times T2_t + \beta_7 Canterbury_i \times Yr2013_t + \beta_8 Canterbury_i \times T2_t \times Yr2013_t + X_c + \delta_{iy} + \varepsilon_{ict}$$

Equation (3.2) specifies the regression of interest, which we use to identify whether students from Canterbury, with previous earthquake exposure, are differently affected by the 2013 earthquake, relative to students at VUW who are not from Canterbury. This triple-differences model includes $Canterbury$, an indicator which equals one if the student attended high school in Canterbury. Using this model, we compare the differences for students who attended high school in Canterbury to students who did not attend high school in Canterbury[15], Trimester 2 to Trimester 1 performance, and Trimester 2 performance in 2013 to Trimester 2 performance in all other years. Given that the effect may decline over time, we later allow for time-variant effects. Again, it contains individual-by-year fixed effects and controls for subject. The triple difference model relies on the identifying assumption that in the absence of the 2013

[15] While we cannot identify how many exposed Canterbury high school students went on to graduate from a school in another region, these additional students would be added to the much larger counterfactual group so should not affect the results.

earthquake, the 2013 difference in Trimester 1 and Trimester 2 between Canterbury and non-Canterbury students would be similar to the difference in Trimester 1 and Trimester 2 for students from Canterbury relative to students from elsewhere in other years. We demonstrate that our results are not driven by affected selection into VUW as a result of the Christchurch earthquake.

Results

Table 3.2 presents our basic results for equation (3.1). Column (1) includes covariates for trimester and year only. Column (2) adds controls for gender, ethnicity, subject and year, and column (3) adds individual fixed effects. Column (4) adds individual-by-year fixed effects. Column (4) shows that grades in Trimester 2 courses are 0.03 standard deviations lower compared to grades in Trimester 1. The coefficient for the interaction between Trimester 2 and 2013 is close to zero and not statistically significant, suggesting no overall impact of the 2013 earthquake.

Table 3.3 shows the results for the triple-difference model in equation (3.2). The columns use the same specifications as in Table 3.2. Column (2) shows that students from Canterbury achieve grades that are higher by 0.09 standard deviations. Column (4) shows precisely estimated zero effects for interactions between 2013 and Trimester 2, Canterbury and Trimester 2, and our coefficient of interest, students from Canterbury in Trimester 2 of 2013.

Timing and Pre-existing Trends

One concern is that our triple-difference identification strategy may be unable to disentangle different trends between treatment and control students. If the 2013 earthquake occurred when grades were exogenously deteriorating for Canterbury students, the results may be biased. We address this point by plotting the estimated coefficients and confidence bands on our outcome variable and indicator variables for each year in the years preceding and following 2013 (Figure 3.1). This equation takes the form

(3.3)

$$GRADE_{ict} = \beta_1 + \beta_2 Canterbury_i + \beta_3 T2_t + \beta_4 Yr2013_t + \sum_{j=2008}^{2016} \beta_5^j T2_t \times \mathbb{I}\,(y = j) + \sum_{j=2008}^{2016} \beta_6^j Canterbury_i \times T2_t \times \mathbb{I}\,(y = j) + X_c + \delta_{iy} + \varepsilon_{ict}$$

Equation (3.3) is an extension of the difference-in-difference-in-difference model in equation (3.2). Figure 3.1 plots the interaction between Canterbury and Trimester 2 by year, and shows that Canterbury student grades were not differently affected compared to non-Canterbury students when the 2013 earthquake occurred. However, it does show a negative but non-significant impact on grades in Trimester Two of 2010 for Canterbury students. This result may be the 2010 earthquake effect, which struck just before the start of term.

Selection bias

As noted above, one concern with our empirical strategy is that students induced by the earthquake may have different outcomes and bias our results. This threat is plausible, since Cuffe and Wills (2018) find the Christchurch earthquake increases university enrolment for Canterbury school leavers, particularly for low ability students. However, due to data-use requirements, the authors cannot identify the effect on enrolment at specific universities. To address this concern, we investigate the change in demographics for first year students over time, and whether this change is different for students from Canterbury. We also identify whether there is a change in Trimester 2 compared to Trimester 1 performance for first year students from Canterbury in 2012, when those affected by the earthquake first enrol.

To investigate the change in observable demographics, we regress the observable characteristics of gender and ethnicity on indicator variables for each year, then interact the years with Canterbury status, to identify if there is a different trend. Figure 3.2 shows changes in characteristics of first year students over time, where 2008 is the reference year. In line with Cuffe and Wills (2018), Panel A shows there is a significant increase in the percentage of students enrolling at VUW from 2012 onwards. Panel B shows there is a significant drop in women enrolling in 2012, with 4 percent less than in 2008. Panels C and D show a steady increase in Māori and Pasifika students from 2014 onwards.

We can compare Figure 3.2 to Figure 3.3, which shows estimates from the interaction terms between Canterbury and year, identifying the change in characteristics of students from Canterbury who enrol at VUW for the first time. Panel A shows that relative to non-Canterbury students, the proportion of female students enrolling from Canterbury is stable over time. Panels B and C show no statistically significant change in the number of Māori and Pasifika students enrolling from Canterbury in 2012 – 2014.

Since we use individual-by-year fixed effects, a change in student enrolment is a problem only if those students induced by the earthquake have different Trimester 2 compared to Trimester

1 performance. In Figure 3.2, we see the increase in first enrolment of Canterbury students starts in 2012. Therefore, if there are differences in Trimester 2 performance for new students from Canterbury, we would expect to see these changes in 2012. Using a sample restricted to first year students, we identify whether there is a change in Trimester 2 performance using equation (3.3). The results are shown in Figure 3.4. Since we find no different effect in 2012, our results are not driven by selection.

Heterogeneity

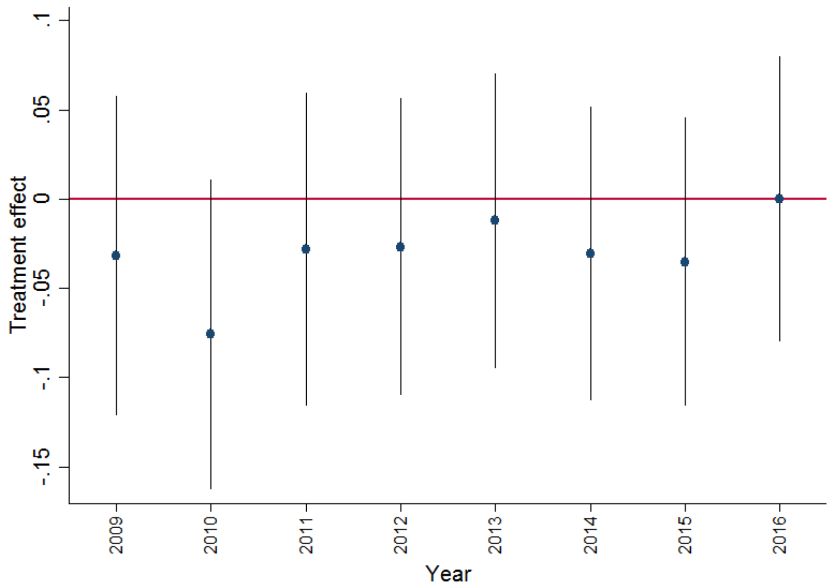
We examine specific subsets of our data to identify whether groups of students are differently impacted by repeat earthquakes. We consider whether there is a different effect according to gender, and exclude students who attended high school in Wellington. To assess the difference, we use equation (3.3), splitting the sample and allowing the Canterbury coefficient to vary for each sample. The results are shown in Figure 3.5. These graphs show no significant effect in Trimester Two of 2013 for any subset.

Conclusion

Evidence suggests that experiencing a disaster may reduce resilience to future disasters. To address this question, we use enrolment data for VUW, a university which was subject to an earthquake in the second trimester of 2013. We identify whether students who have previously experienced a disaster respond differently in subsequent disasters, relative to students who have no prior experience. We find the 2013 earthquake has no impact on grades for all students, and the effect is no different for students who have previous earthquake experience. We find this null effect is robust by subgroup.

There are several possible reasons why grades for students from Canterbury are not differently affected. Firstly, if some students from Canterbury have increased resilience to shock, and others have reduced resilience to shock, these effects may cancel each other out. Secondly, the 2013 earthquakes may not be of significant magnitude to induce a psychological response. Thirdly, the most affected students may not have selected in to attending VUW. Further, any psychological response induced may not have translated into affected academic performance.

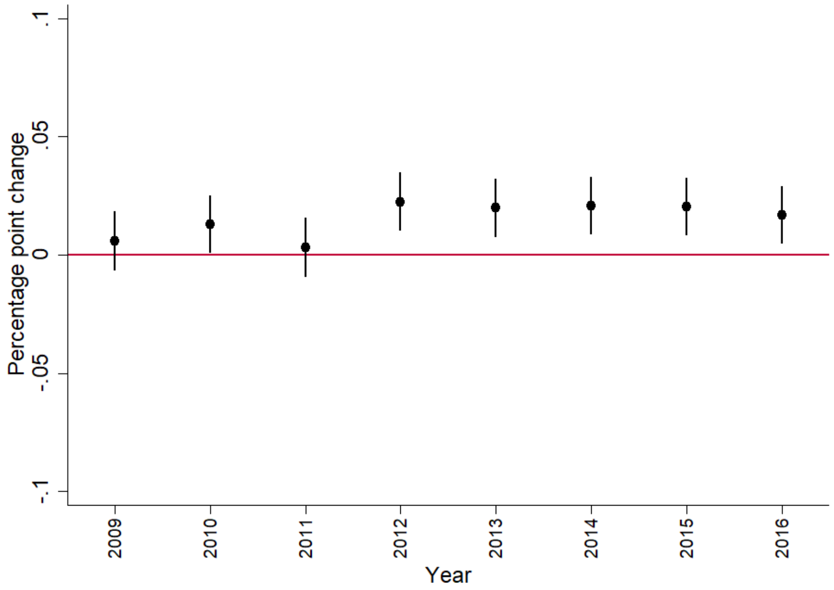
Figure 3.1. Additional impact of Trimester 2 grades for students from Canterbury, by year



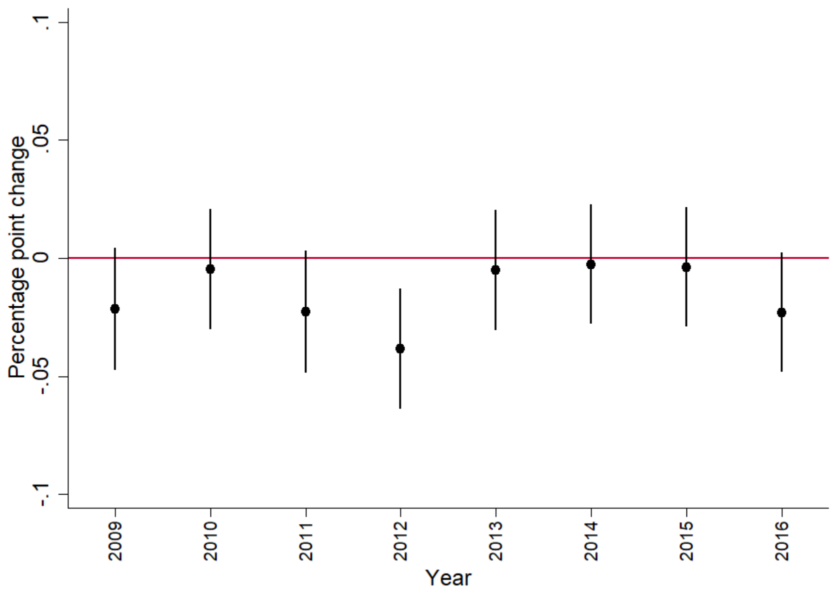
Notes: Outcome is grade (0-9) during trimester. Coefficient plot of interaction between Canterbury, Trimester 2 and year, shown by year, using equation (3.3). Includes individual by year fixed effects. Spikes show 95% confidence interval. Reference year is 2008.

Figure 3.2. Change in characteristics of first year students

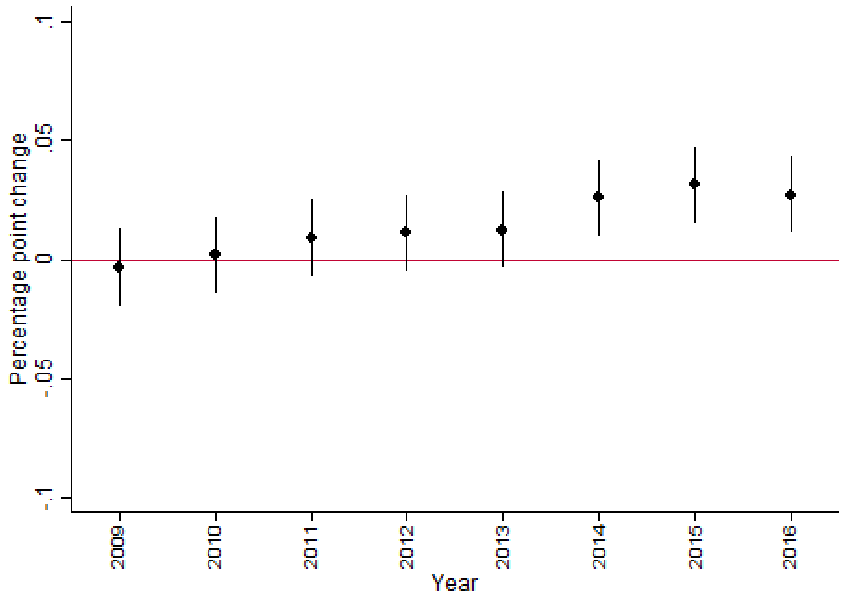
Panel A – First enrolment of students from Canterbury



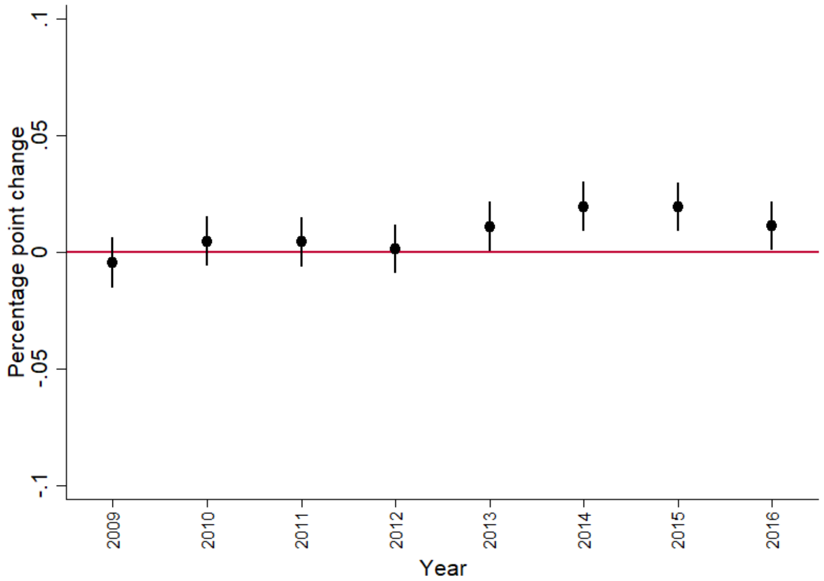
Panel B - First enrolment of female students



Panel C – First enrolment of Māori students



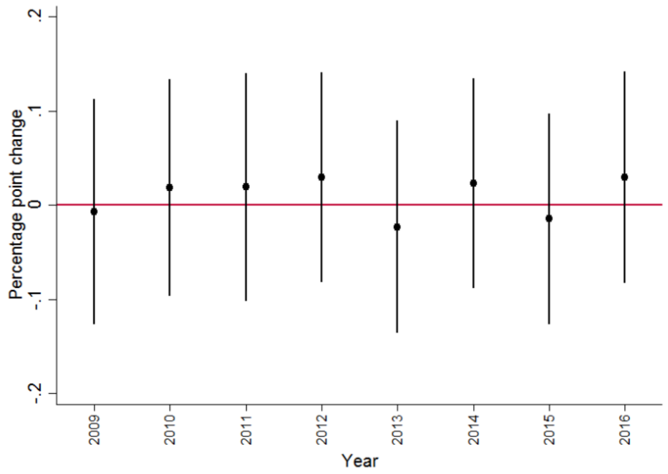
Panel D – First enrolment of Pasifika students



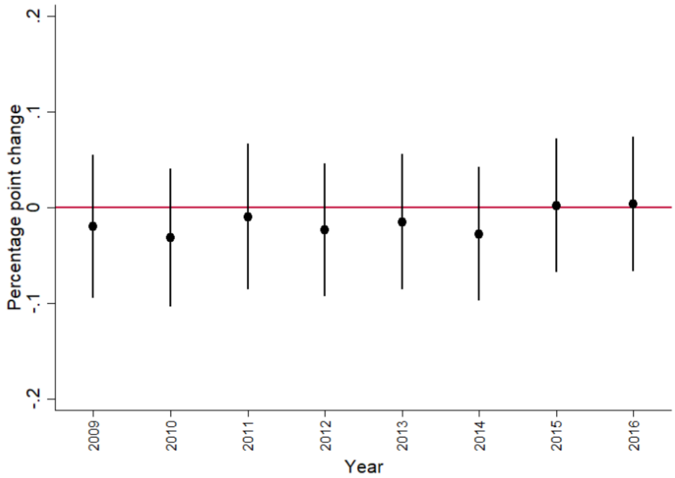
Notes: Sample includes first years. Outcome is indicator for: Panel A: From a Canterbury school; Panel B: female; Panel C: Māori; Panel D: Pasifika. Reference year is 2008. Spikes show 95% confidence interval.

Figure 3.3. Change in characteristics of first year students from Canterbury

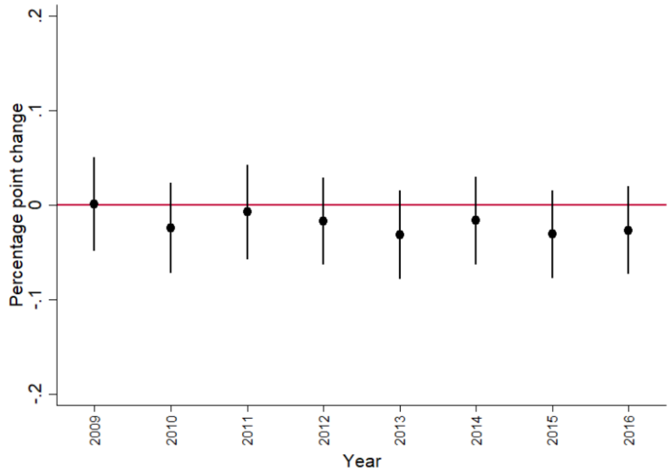
Panel A – First enrolment of female students from Canterbury



Panel B – First enrolment of Māori students from Canterbury

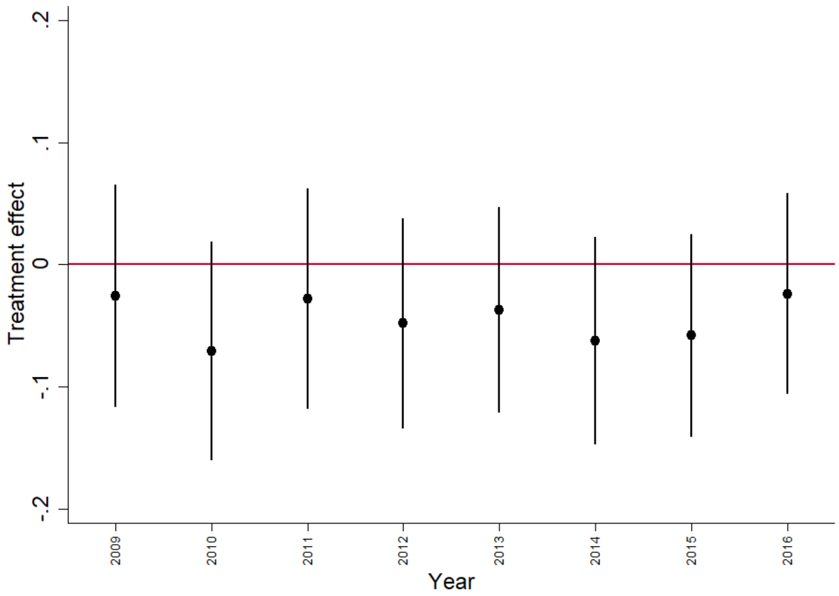


Panel C – First enrolment of Pasifika students from Canterbury



Notes: Sample includes first years. Outcome is indicator for: Panel A: female; Panel B: Māori; Panel C: Pasifika. Plots interaction between indicators for each year and Canterbury status. Reference year is 2008. Spikes show 95% confidence interval.

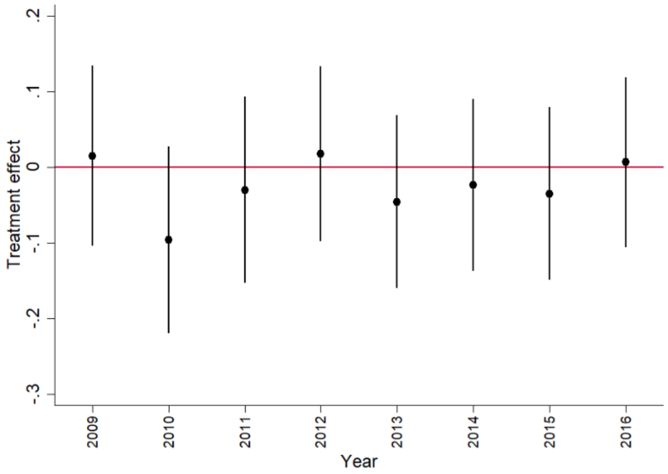
Figure 3.4. Trimester 2 performance for first year Canterbury students



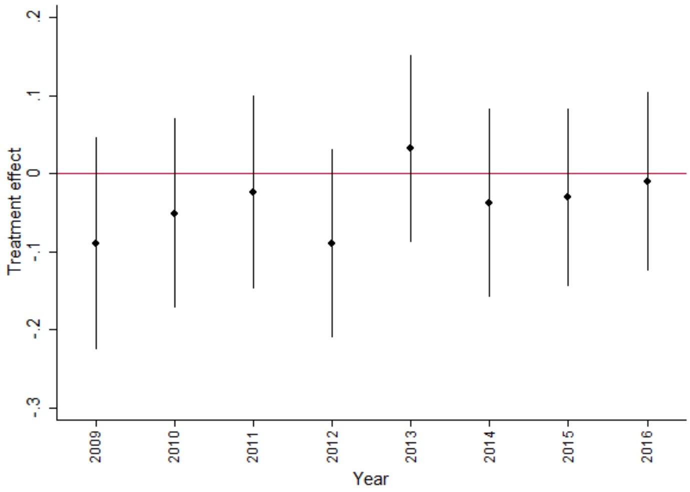
Notes: Sample includes first years. Outcome is grade (0-9) during trimester. Includes individual by year fixed effects. Plots interaction between Canterbury status and Trimester 2 performance for each year. Reference year is 2008. Spikes show 95% confidence interval.

Figure 3.5. Heterogeneity in impact of 2013 earthquake on grades for students with previous earthquake experience: Triple difference event study by sub-group

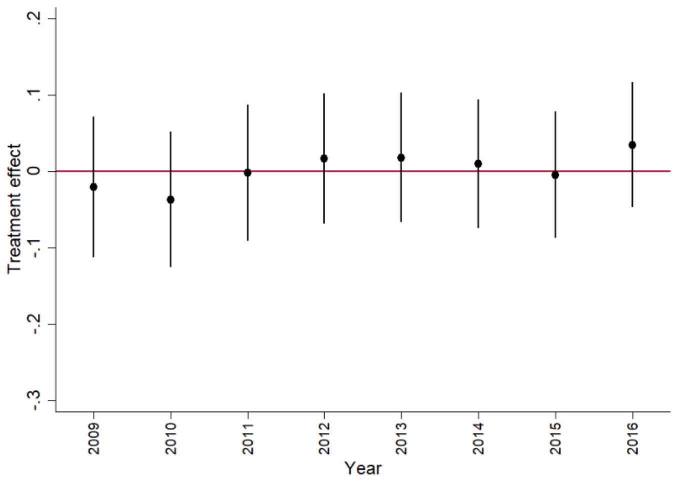
Panel A – Female only



Panel B – Male only



Panel C – Excluding Wellington



Notes: Split sample coefficient plot of interaction between Canterbury, Trimester 2 and year, shown by year. Spikes show 95% confidence interval. Reference year is 2008.

Table 3.1. Sample means

	Full sample		Canterbury students		Non-Wellington, non-Canterbury students	
	Mean	SD	Mean	SD	Mean	SD
Percent Trimester 2 (1[Trimester=2])	49.47	50.00	49.02	49.99	49.59	50.00
Percent Grade A (1[Grade=A])	26.91	44.35	33.51	47.20	26.88	44.33
Percent Grade B (1[Grade=B])	43.80	49.61	44.85	49.73	44.79	49.73
Percent Grade C (1[Grade=C])	17.11	37.66	13.24	33.89	16.69	37.29
Percent Grade D (1[Grade=D])	4.15	19.95	2.65	16.06	3.84	19.22
Percent Grade E (1[Grade=E])	8.04	27.19	5.75	23.28	7.80	26.82
Student characteristics						
Age at first enrolment	18.37	0.66	18.42	0.68	18.58	0.83
Percent from Canterbury	5.77	23.32	-	-	-	-
Percent from Wellington	44.24	49.67	-	-	-	-
Percent Māori	10.71	30.92	5.38	22.56	13.16	33.80
Percent Pasifika	4.42	20.57	1.48	12.48	2.27	14.90
Percent female	55.81	49.66	58.09	49.35	58.06	49.35
Number of students	32,844		1,897		16,417	

Table 3.2. Impact of 2013 earthquake on grades for all students

N = 438,119	(1)	(2)	(3)	(4)
Trimester 2	-0.00408	-0.00857***	-0.0249***	-0.0334***
	(0.00271)	(0.00256)	(0.00226)	(0.00227)
2013	0.124***	0.0595***	0.0775***	-
	(0.0140)	(0.0134)	(0.00941)	
2013*Trimester 2	-0.00806	-0.00399	0.00004	-0.00408
	(0.00825)	(0.00767)	(0.00673)	(0.00670)
Controls	No	Yes	Yes	Yes
Individual FE	No	No	Yes	.
Individual by Year FE	No	No	No	Yes
Mean Trimester 2 grade in years excluding 2013	4.73	4.73	4.73	4.73
	(2.53)	(2.53)	(2.53)	(2.53)

Notes: Column 2 includes controls for gender, ethnicity and subject, and year fixed effects. Column 3 adds individual fixed effects. Column 4 adds individual by year fixed effects. Robust standard errors are corrected for clustering within individual. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.3. Additional impact of 2013 earthquake on grades for students from Canterbury

N = 438,119	(1)	(2)	(3)	(4)
2013*Trimester 2	-0.00747	-0.00342	-0.000951	-0.00512
	(0.00854)	(0.00793)	(0.00696)	(0.00692)
Canterbury*Trimester 2	-0.0307***	-0.0174	-0.0136	-0.0122
	(0.0113)	(0.0107)	(0.00962)	(0.00975)
Canterbury*2013*Trimester 2	0.00146	-0.00551	0.0161	0.0175
	(0.0322)	(0.0307)	(0.0273)	(0.0274)
Controls	No	Yes	Yes	Yes
Individual FE	No	No	Yes	.
Individual by Year FE	No	No	No	Yes
Mean Trimester 2 grade in	4.73	4.73	4.73	4.73
years excluding 2013	(2.53)	(2.53)	(2.53)	(2.53)

Notes: Column 2 includes controls for gender, ethnicity, and subject, and year fixed effects. Column 3 adds individual fixed effects. Column 4 adds individual by year fixed effects. Robust standard errors are corrected for clustering within individual. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

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4 THE EDUCATIONAL CONSEQUENCES OF INJURIES

Introduction

Unexpected injuries pose a major disruption to human capital development. Injuries affect students by adding barriers to attending class, and injured students who *do* attend are likely to have reduced concentration and attention. Given the positive causal effect of education on wages (Card (1999), Harmon, Oosterbeek, and Walker (2003), and Ashenfelter, Harmon, and Oosterbeek (1999)), the long term financial consequences of disrupted education may be large. Since health insurance tends to cover only treatment costs and direct lost earnings, it is likely students face uninsured long-term financial consequences when injured during their education years. Despite these potentially high costs, we know little about how injuries affect student outcomes.

In this paper, we examine the relationship between a wide range of acute injuries on university students' education outcomes and short-term labour supply in New Zealand. To do so, we access nationally comprehensive administrative data linking course-level tertiary data with public insurance claims, ED attendance, hospital admissions, and monthly tax returns. With this data, we estimate the effects of injuries on subsequent university re-enrolment, degree completion, course passage rates, and wages during university. While we find injuries negatively affect all students, the effects are most pronounced for first year students who experience serious injuries; injuries leading to an emergency department visit reduce re-enrolment by 2.5 percentage points, and degree completion by about 3 percentage points. Injuries resulting in a hospital admission decrease re-enrolment by 4 percentage points, and degree completion by 3.4 percentage points. As nearly one-in-ten students in our sample experience a serious injury during their course of study, the number of people who drop out because of injury is large.

Identifying the impact of health on human capital accumulation is challenging for several reasons. First, the direction of causality between health and education is not always clear. For example, health status and education attainment are both positively correlated with socio-economic status (Adler and Ostrove (1999), Currie (2009) and Sirin (2005)). Students with richer parents may have better access to doctors and could have received greater educational investments as children. Similarly, sports may lead to injuries while also improving student performance (Cuffe, Waddell, and Bignell (2017) and Taras (2005)) . The degree to which this endogeneity biases naïve correlational summaries of injury's relationship with education away from injury's causal effects is ambiguous.

Another challenge arises from error and omissions in health reporting (Ding et al. 2009). Data recording health status often use self-reported surveys, which rely on accurate recall, may be subjective and are not easily comparable between people. However, objective administrative data are no panacea, and can be incomplete if injured people fail to seek treatment. The consequences of this incompleteness are likely especially pronounced when there is significant heterogeneity in access to healthcare, and financial costs are borne by the injured.

We address these estimation issues through several means. First, it is convenient that our administrative data come from New Zealand, which has in place a no-fault insurance scheme that does not discourage seeking treatment. The Accident Compensation Corporation (ACC) funds treatment for all accidental injuries, has no incentive to withhold claims, and is administered by the medical practitioner, requiring little input from the injured person. A study in a country such as the U.S. may spuriously imply that injuries *raise* performance if poor students are unable to afford medical treatment and have lower academic achievement for various other reasons.

To account for the possibility of endogeneity bias, we employ a number of strategies. First, our data provide important controls which proxy for potential confounding variables. This includes high school academic performance, and a measure of socio-economic status. The panel nature of our data further allows us to approximate an experiment where comparable students randomly experience health shocks. In many regressions, we include semester-schedule fixed effects, thus restricting attention to variation in injury across individuals taking the exact same schedule of courses. Additionally, in some regressions, we account for individual fixed effects, and compare a student's performance in the semesters where she was and was not injured. Lastly, we separately identify the effects of injuries of various levels of severity. If selection into seeking treatment for minor injuries correlates with academic performance, this measure will mitigate against selection biasing estimates of the effects of the more serious injuries.

Finally, as our goal is to estimate the effects of idiosyncratic injury "shocks" on students, we must account for chronic illness and individuals who appear to be "accident prone." Dobkin et al. (2018) focus on this type of shock by restricting their sample to individuals who do not experience a hospital admission two to three years prior to the injury of interest. As our data allow us to investigate common minor injuries, we choose to simply control for prior injuries in the two years prior to tertiary enrolment, rather than drop the proportionally large part of our population which experience a prior injury. We confirm our results are robust to restricting our sample to students who have at most two recorded injuries in the five years prior to first enrolment. We further use information on the cause and nature of the injury to better identify plausibly exogenous injuries sustained through more versus less risky activities (e.g. self-harm and sports versus driving-related accidents).

While we study the impact of injuries, our research is aligned with literature on health shocks more broadly. Health shocks include all unexpected diseases, conditions and injuries, commonly defined by hospital admission or ED presentation, while injuries cover a subset of health shocks, including a wide range of externally caused injuries and excluding general illnesses, diseases and conditions. Existing research on the impact of health shocks on human capital focuses on the adult working population, commonly identifying the impact on income and employment. Our research builds on those using administrative panel data, including Dobkin et al. (2018) who identify the impact of hospital admission on earnings, out-of-pocket medical spending and borrowing. The authors find substantial declines in earnings, with non-elderly insured adults experiencing declines in average earnings and the probability of being employed. Crichton, Stillman, and Hyslop (2011) use New Zealand data to identify the impact of injuries on employment, using duration of earnings compensation as a proxy for injury severity. They find that injuries resulting in at least four months of earnings compensation have negative effects on future labour market outcomes, and those with an injury spell of 7 to 24 months have lower employment rates, and lower earnings after compensation ends. Several other papers use econometric techniques to identify negative impacts on wages of a variety of health shocks, including road injuries (Dano 2005), commuting accidents (Halla and Zweimüller 2013), acute hospitalisation (García-Gómez et al. 2013), and weather-induced ill-health (Chadi 2017).

There is extensive literature on the impact of in-utero health (including Almond (2006), Almond and Mazumder (2005), Almond, Edlund, and Palme (2009) and Barreca (2010)), and birthweight (including Currie and Hyson (1999), Black, Devereux, and Salvanes (2007) and Royer (2009)) on education outcomes later in life. In addition, many researchers identify the effect of time spent in the classroom on academic performance (including Angrist, Pathak, and Walters (2013), Lavy (2015) and Pischke (2007)). However, research on the impact of health shocks during education is limited (Currie 2009). One reason for this omission may be poor data availability. An exception is literature on the impact of sport-related concussion on academic performance, which is currently a popular research focus. Ransom et al. (2015) investigate the effects of concussion on high school students using parent reports of academic performance, and find students face adverse effects four weeks post-injury. Moser, Schatz, and Jordan (2005) use neuropsychological evaluations and clinical interviews on a sample of high school athletes, and find athletes with recent concussions demonstrate worse attention and concentration than those with no concussion history. For comparability, we separately identify the effect of head injuries on student performance, and find greater negative impacts compared to other injuries.

Background

The New Zealand Accident Compensation Corporation

The Accident Compensation Corporation (ACC) is a unique state-run insurance system which contributes towards the direct medical costs of accidental injuries, income replacement and rehabilitation. ACC cover is decided on an individual basis and requires a clinical diagnosis, meaning all claims are assessed and completed by a medical practitioner. Information about the injury is submitted in a standardised format. The injured person completes information about location, activity prior to injury, and cause, along with personal details. Importantly, there is no disincentive for making claims, and people are not risk-rated or penalised for the number of claims they make.

While the presence of ACC reduces concerns of under-reporting of injuries due to cost, there are still barriers to reporting injuries, such as remaining fees and time spent in consultation. Since the medical practitioner acts as gatekeeper, the student needs to have access to a health provider for full injury reporting. GP fees likely do not present a major barrier for our sample, because universities offer free or subsidised health services. There is some variation across universities; for example, Victoria University of Wellington has no charge for GP consultations for domestic students, while at the University of Otago, GP consultations can cost NZ$10-25. The extent of other university health services is limited, but GP consultations are the most important for accessing further ACC funded services.

Tertiary education in New Zealand

There are eight main universities in New Zealand. The academic year is split into two main semesters; semester one runs from February to June, and semester two runs from July to November. A Bachelor’s degree typically takes three years to complete, so most full-time students enrol in six semesters of study before graduation. All eight universities provide student health services, although students may remain registered with their previous health practitioner. If students are injured while at university, they can obtain a medical certificate from the university healthcare provider. The course coordinator may apply exemptions or adjusted grades at their discretion. These actions are not documented in our administrative data. Since we do not know when adjusted grades are applied, it is likely our estimates on passing all courses understate the effect of injuries on academic performance.

Data

We use the Integrated Data Infrastructure, a centralised administrative database in New Zealand linked at the individual level. We identify domestic students[16] who enrol full time in their first Bachelor's degree between 2008-2017 at one of the eight main universities, are aged 17-20 at the time of first enrolment, do not suffer a fatal injury and have no ACC record of self-harm. We limit students to their first three years, or six semesters, of study, because this covers the duration of most Bachelor's degrees. We link these students to all ACC claims, outpatient and inpatient data during time in enrolment. ACC claims data covers all injuries which are seen by a health provider, and includes the date of injury, activity prior, and type of injury. Outpatient data covers all non-admitted patient events, including ED attendance. We categorise an injury as an emergency if the student attends ED within seven days of the injury. Hospital data identifies the date and length of stay in hospital, and whether it is the result of an injury. We categorise an injury as a hospital admission if the student is admitted to hospital within seven days of the injury. We use these distinctions to categorise the injury severity, summarised in Table 4.1.

Table 4.2 presents basic summary statistics for our primary analysis sample, for all students, and for students who ever (2) make an ACC claim; (3) go to ED; or (4) are admitted to hospital while a student. In our analysis, these categories are mutually exclusive. If the student experiences more than one injury type in a semester, they are assigned to the category of greatest severity. Overall, 31 percent of students make an ACC claim, 7 percent attend ED and 2 percent are admitted to hospital while enrolled at university. Since we may be concerned that both the probability of getting injured and re-enrolling are correlated with socio-economic status, we report school decile category for each column. School decile is a categorisation for publicly funded schools in New Zealand, which assigns the school a number from 1-10 based

[16] International students are covered by private health insurance, so are therefore excluded from the sample.

on the socio-economic make-up of the school catchment area. Low decile schools are expected to have a higher proportion of disadvantaged students, and receive more public funding per student. In our sample, the number of students in each decile group is not equal because students from higher decile schools are more likely to enrol in university. In Table 4.2, we see injured students are more likely to have attended a higher decile school and are less likely to be female. In Panel B, we show the probability of passing all courses in the first semester for students who go on to be injured compared to students who are never injured. This shows a higher probability of passing all courses for injured students compared to non-injured students when we exclude the semesters of injury. While these results may indicate that there is positive selection into injury by better students, it is more likely that better students select into more semesters of study, thus providing more time in which to be observed experiencing an injury (compared to students who are only enrolled for one semester). To ward against bias from this latter type of selection, we stratify many of our results by year-of-study. We also include controls for total EFTS (Equivalent Full-time Student), a measure of the number of credits taken per semester. One course is typically 0.125 EFTS, so taking four courses in a semester is equivalent to 0.5 EFTS.

Empirical Strategy

Impact of injury on re-enrolment and degree completion

To identify the impact of injuries on re-enrolment, we stratify the sample by year of study and estimate;

$$(4.1) \qquad Y_{iys} = \alpha + \beta_1 Minor_{iys} + \beta_2 ED_{iys} + \beta_3 Hospital_{iys} + EFTS_{iys} + \gamma_c + x_s + \mu_q + \boldsymbol{x}_i{}'\Pi + \varepsilon_{iys}$$

where the outcome Y is (1) an indicator for re-enrolling the following semester; (2) an indicator for re-enrolling the following year; and (3) an indicator for completing a degree within four years. We include indicators for semester x_s, calendar year γ_c, and schedule fixed effects μ_q, which is equivalent to an indicator for each observed combination of classes taken concurrently within a semester. To interpret the injury coefficients β_1, β_2 and β_3 in equation (4.1) as the causal effect of an injury requires the assumption that the probability of sustaining an injury of each severity is the same across students, conditional on our fixed effects and control variables. If, for example, injuries are more common amongst active-people, and students participating in sports are also more likely to re-enrol, we are not only identifying the effect of the injury but also the effect of participating in sports. Given that scholars find sport has positive associations with academic outcomes (Cuffe, Waddell, and Bignell (2017), Fox et al. (2010)), this is a plausible threat to validity. We partially address this threat by including the column vector $\boldsymbol{x}_i$, which comprises controls for gender, which high school the student attended, indicators for grades in high school[17], and an indicator for being injured in the two years prior to tertiary enrolment. Gender is an important control because men are more likely to be injured (Table 4.2) and have poorer student outcomes on average. Including high school grades means we can account for being a better performing student prior to university enrolment. The indicator for prior injury captures differences in existing propensity for injury. While these controls may accurately capture the determinants of grades which correlate with injury risk, it remains possible that a student's circumstances may change while at university, which dictates changes in grades and injury risk. Perhaps the greatest concern is variation in the intensity of exercise or sports participation from one semester to the next. Similarly, students might shift into a job requiring significant time driving, therefore raising the probability of a motor vehicle related injury. To avoid attributing the effects on grades from activity-related shifts in time-use, in the second part of the paper, we separately identify the effects of sport- and vehicle-related injuries compared to other injuries. We find that injuries incurred from these activities do not produce effects markedly different from other injuries.

Results

We stratify the sample because we expect the effects of injury to vary by year of study. For example, first year students have invested less in education, so may be more inclined to drop out following an injury since their opportunity cost of dropping out is relatively low. Final year students who have spent three years at university and are closer to completing a degree may be prevented from dropping out due to their perception of a comparatively high opportunity cost. Table 4.3 shows the effects of injury on three education outcomes, broken out by injury severity and year of study. Panel A column (1) shows that, for first year students, minor injuries, ED attendance and hospital admissions reduce the probability of university re-enrolment in the following semester by 0.6, 1.5 and 4.0 percentage points ($p < 0.01$), respectively. These magnitudes are smaller for second year students (Panel B), who only see a statistically significant effect for hospitalised students, decreasing re-enrolment by 2.6 percentage points. Column (2) shows the effects of injuries on re-enrolling in the following year, because students

[17] The sample is not restricted to students who attend school in New Zealand. However, in our sample, only 4.8% is not matched to school data. Students with grades missing are included in the omitted category.

injured in the first semester may struggle through the second, but ultimately drop out. Thus, we interpret re-enrolment next year as a longer-term outcome. Here, we see larger decreases in re-enrolment for first year students, by 1.2, 2.5 and 5.2 percentage points for minor injuries, ED and hospital admissions. Again, second year students only see significant negative effects for hospital admissions, with a 2.7 percentage point decrease in re-enrolment. Column (3) shows the results for completing a degree within four years (one year after typical full-time students are projected to graduate). Given the wage premium associated with a degree (Blundell et al. (2000), Hungerford and Solon (1987)), degree completion is an important outcome. Here, we restrict the sample to students who first enrol before 2016 to allow time for completions to be reflected in the data. Again, we find first year students are the most affected, decreasing completion rates by 0.6, 2.9 and 3.4 percentage points. Second year students again see statistically significant effects for those hospitalised, decreasing completion by 3.2 percentage points. For third year students, we only estimate the results for degree completion. Since the third year is generally the final year, the effects of injury on re-enrolment would have very different interpretations compared to first and second years, suggesting either failure to pass previously or enrolment in post-graduate study. Third year students see no statistically significant impact of injuries on completing a degree within four years. In Table 4.4, we show results when the sample is restricted to those with a maximum of two injuries in the five years prior to first enrolment. These results are a similar magnitude, suggesting our results are not driven by students who are more injury-prone. Table 4.5 shows the results when our full sample is stratified by year-by-semester, and again the results do not meaningfully differ from Table 4.3.

Injury timing and re-enrolment

We next investigate whether there are heterogeneous effects depending on the timing of injuries. Injuries happening nearer the beginning of term may leave students with an entire semester of affected study, which could be more damaging to performance. At the same time, injuries occurring during the exam period may have more serious consequences, given their proximity to assessment. To determine whether injury timing affects outcomes, we include indicators for whether the injury occurs in the first twelve weeks of study to identify ‘term-time’ or the last 4 weeks to identify ‘exam-time’. Table 4.6 shows the results. Given that term-time is longer than exam-time, it is not surprising that the standard errors are larger in the exam period. For first year students (Panel A), we see minor injuries and hospital injuries in exam time are more detrimental than those in term time, reducing re-enrolment the following semester by 1.4 percentage points in exam-time compared to 0.4 percentage points in term-time for minor injuries, and 6.5 percentage points in exam-time compared to 3.5 percentage points in term-time for hospitalisation. However, ED injuries only have a statistically significant decrease of 1.6 percentage points in term-time. In column (2), minor injuries also have a larger effect on re-enrolment the following year in exam-time than in term-time, decreasing by 1.7 and 1.1 percentage points, respectively. Again, ED injuries are only statistically significant for term-time, decreasing re-enrolment by 2.4 percentage points. Hospital injuries have similar magnitudes in both time periods, decreasing re-enrolment by 5.2 percentage points in term- and exam-time. Column (3) shows the effect of injury timing on completing a degree in four years. Interestingly, we see statistically significant decreases in completion for ED injuries in term time, by 3.1 percentage points, and hospital injuries in exam time, by 11.5 percentage points, a substantially larger magnitude than other estimates. When using F-tests, this is the only result in Table 4.6 where the exam-time coefficient is statistically different to the term-time coefficient (Prob > F 0.0121). This difference in magnitudes suggests that those who do re-enrol following a hospital admission drop out later. In general, we find exam period injuries are more damaging. It is surprising that ED injuries are more damaging in term-time, while both minor injuries and hospital injuries are more damaging in exam-time. One possible reason for this could be that students with ED injuries during the exam period have already learnt course material, so re-enrol to re-take the course, whereas students with ED injuries during the term still have several weeks of affected learning ahead of them. Despite having also learnt the material, students with hospital injuries during exam time may expect the severity of their injury to affect performance into the next year, so do not re-enrol.

Across all three columns, second year students (Panel B) see statistically significant effects only for hospital injuries in exam time, decreasing re-enrolment the following semester by 6.0 percentage points, re-enrolment the following year by 6.7 percentage points, and completion by 9.9 percentage points. Again, third year students (Panel C) see no statistically significant impact of injuries on completion.

Location of injury and re-enrolment

Another source of heterogeneity arises from the nature of the injury. We expect the impact of injuries to differ depending on how the injury affects the student’s functioning; for example, previous research demonstrates that head injuries can negatively affect cognition, and injuries affecting the ability to write or type may add additional challenges for student learning. We categorise injuries according to whether they affect (1) any part of the head excluding the face; (2) lower body, including hip, leg and foot; (3) upper body, including shoulder, arm and hand; (4) back injuries, including the neck; (5) any injury affecting the face, and (6) other injuries, which mostly consist of internal injuries. The categories are not mutually exclusive; students may suffer several injuries in one event. Table 4.7 presents a basic summary on the most common injury types, by location on the body. While this does not fully explain the nature of the injuries, it does provide a useful comparison between categories. 45 percent of head injuries are concussion-related. 11 percent of upper body injuries are fractures or dislocations, which is a higher proportion compared to lower body injuries, which are 4 percent. It is also worth noting that 89 percent of back injuries are sprains, and it is possible that some back sprains are study-related. This injury sub-set may identify reverse causality if spending more time studying causes back injuries.

Table 4.8 shows the results when we separate injuries by location. For first year students (Panel A), upper body, back and other injuries decrease re-enrolment the following semester by 1.0, 1.4 and 2.2 percentage points. Interestingly, head injuries are not statistically significant for re-enrolment the following semester, but they do have the largest effect on re-enrolment the following year, which decreases by 2.4 percentage points, suggesting that those who are injured and remain then go on to drop-out later. The only injuries to affect degree completion are upper body, which decreases by 1.9 percentage points. Since the magnitudes are similar, we may attribute this to lack of variation in other injuries rather than lack of effect. In Panel B, we see that the only injury to affect second year students for any outcome is back injuries, which decrease re-enrolment next semester by 0.9 percentage points. In Panel C, we see no statistically significant effects on third year students.

Impact of injury on passing courses

We now turn to our results when identifying the impact of injuries on passing courses in university. Here, our estimation takes the form

$$(4.2) \qquad Pass\ all_{iys} = \alpha + \beta_1 Minor_{iys} + \beta_2 ED_{iys} + \beta_3 Hospital_{iys} + EFTS_{iys} + \theta_{ys} + \gamma_c + \pi_d + \delta_i + \varepsilon_{iys}$$

where i, y and s index individual, year of study and semester respectively. The outcome is an indicator equal to one if the student passes all courses in the semester. We include controls for calendar year γ_c, year of study by semester θ_{ys}, number of EFTS (a measure of the number of credits a student enrols in), and degree by university π_d, an indicator for each degree enrolled in, for example Bachelor of Science. We also include individual fixed effects δ_i, in order to focus on variation in outcomes within students over time. This reduces concern about bias from omitted factors which correlate with both being injured and passing courses, and are fixed over a student's university career. Since we find that injuries prevent students from re-enrolling, we do not observe how these students would have performed had they hypothetically enrolled in the following semesters. This lack of information means we likely underestimate the true effects of injury on one's capacity for academic study following an injury if the effects of injury persist.

Table 4.9 shows the results for the impact of injury on passing all courses, by model specification. Column (1) includes controls for year, year of study by semester, sex, school attended, total EFTS taken and degree, schedule fixed effects, and column (2) replaces schedule fixed effects with individual fixed effects. Similar to re-enrolment, we find the negative effect on passing courses increases in magnitude as injuries get more severe, with column (1) showing no statistically significant effect of minor injuries, but ED injuries reducing the probability of passing all courses by 3.2 percentage points, and hospital injuries by 6.1 percentage points. Column (2) shows small but statistically significant effects for minor injuries, decreasing the probability of passing all courses by 0.4 percentage points. We find smaller effects for ED and hospital injuries, of 1.3 and 3.5 percentage point drops. While the individual fixed effects estimates are smaller in magnitude, their similarity demonstrates our observable controls capture much of the unobserved heterogeneity that is fixed within a person over time.

Since re-enrolment sees heterogeneous effects when stratified by year of study, we investigate whether this is the case with passing courses, and show stratified results in Table 4.10. As before, we see greatest effects for first year students, who are less likely to pass all courses by 0.7, 4.4 and 7.6 percentage points. Second year students only see statistically significant effects for ED and hospital injuries, which decrease passing all courses by 2.1 and 3.4 percentage points. Third year students only see statistically significant effects for hospital injuries, which decrease the probability of passing all courses by 4.5 percentage points. Similar to the re-enrolment estimates, we find the effects are greatest for first year students, but the difference between years is much smaller for the impact of injuries on passing courses.

Injury timing and course passing

Table 4.11 shows the results when injuries are separated by term- and exam-time. Minor injuries have slightly smaller effects in term-time compared to exam-time, decreasing the probability of passing all courses by 0.4 percentage points during term and 0.6 percentage points in the exam period. Similarly, ED injuries decrease the probability of passing all courses by 1.1 percentage points in term-time and 2.3 percentage points in exam-time. Hospital admission injuries have a smaller effect of 3.0 percentage points in exam-time compared to 3.7 percentage points in term-time. Interestingly, the impact of injury timing is different for passing all courses compared to re-enrolment. While minor injuries and ED injuries have bigger effects in exam-time, hospital admissions are worse in term-time. This difference may be because term-time injuries resulting in hospital admission have a greater effect on attendance than less severe minor and ED injuries.

Injury location and course passing

Table 4.12 shows the results when the estimates vary by injury location. We find head injuries and ‘other’ injuries have the greatest effect, reducing the probability of passing all courses by 1.1 percentage points. Upper and lower body injuries have similar magnitudes of 0.6 – 0.7 percentage point decreases. Back and face injuries have no statistically significant effect. Given that upper and lower body injuries affect students in different ways, it is surprising they have similar effects on passing courses. It is possible that, while the upper body injuries have a greater effect on learning, they do not prevent attendance to the same degree as lower body injuries. We investigate whether our location of injury results are driven by severity, by estimating interactions between location and our severity categories. The results in Table 4.13 show that lower body injuries resulting in hospital admission have much bigger effects than upper body injuries of the same severity, which indicates our results may be driven by time away from university.

Injury cause and course passing

Injuries may have different effects depending on how they are caused. For example, if someone who has recently taken up sports is more likely to suffer a sport-related injury, we may be identifying the effects of a change in time-use, not the effects of injury. Similarly, injuries caused by road accidents may be indicative of car ownership or a job requiring significant driving (e.g. meal delivery or Uber driver), which may itself be correlated with academic outcomes. In Table 4.14 we show the results when we interact the injury with an indicator for being sport-related (Panel A), or an indicator for being road-accident related (Panel B), and find there is no different effect. This suggests our results are not identifying the effect of a change in time-use or activities, but the effect of the injury itself.

Impact of injury on wages in university

Injuries may affect students not just through tertiary outcomes but through employment during university, having direct financial consequences which may be particularly pronounced given the mostly flexible nature of student employment. We link the sample to individual tax returns data, documenting earnings each month, and associate wages in March, April and May for semester one and September, October and November for semester two. Nearly half the sample undertake paid work while studying. We use the individual fixed effects specification in equation (4.2), where the outcome is an indicator for earning above (1) $1000; (2) $2000; (3) $3000; and (4) $4000 during the semester. New Zealand dollars are adjusted to 2019 prices.

Table 4.15 shows the results. Across all columns, we find no statistically significant impact of minor injuries on earnings. We find a negative effect for ED injuries, which decrease the probability of all wage thresholds by 0.04 – 0.08 percentage points. Hospital injuries decrease the probability of all wage thresholds by 1.8 – 2.8 percentage points. Since retail and hospitality are the most common employment choices for students, it is not surprising that we find negative effects of injuries on wages as they often offer flexible hours, and work includes a physical component. It is likely that the consequences for wages add to the effects of injuries on student performance, by introducing an additional financial stress.

Conclusion

Injuries are common and can affect anyone at any time. While injury's impact on earnings, spending and employment is well researched, there is little understanding of how injuries affect student performance, which does not benefit from insurance protection. Using a rich administrative panel dataset linking education, no-fault injury insurance, public health services and tax returns, we explore the consequences of injuries for education outcomes. We find that injuries reduce the probability of re-enrolling, completing a degree on time and passing all courses. While estimates for minor injuries are small, we demonstrate that even injuries which do not require emergency medical attention can have long term consequences for students. We find that first year students are less likely to re-enrol following an injury, and are less likely to complete a degree on time. Further, we find larger negative effects for degree completion than re-enrolment, indicating that those who persevere with study may go on to drop-out later. While we cannot say if remaining or leaving university following an injury is ultimately more beneficial for the student, our results do suggest that current education policy for injured students fails to fully counteract these unexpected events.

In our sample, we conservatively estimate about 800 students do not complete a degree on time due to an injury, setting these students on a very different trajectory. Given that a third of students are injured at some point during university, and student retention is a policy concern, our findings suggest that resources be directed to improve accident prevention, or improve opportunities for learning away from the classroom.

Table 4.1. Injury severity categorisation

Not injured	Minor injury	ED	Hospital
No ACC claim	Make any ACC claim, excluding injuries resulting in fatality or self-harm	Student attends emergency department within seven days of ACC claim	Student is admitted to hospital within seven days of ACC claim

Notes: Injury severity categories are mutually exclusive. If students experience more than one injury during a semester, they are assigned to the highest category of injury they sustain.

Table 4.2. Summary statistics

	(1) All	(2) Minor injury	(3) ED	(4) Hospital
Panel A. Demographics				
Female	0.566	0.520	0.469	0.450
	(0.496)	(0.500)	(0.499)	(0.498)
Age at first year	19.1	19.1	19.0	19.0
	(0.91)	(0.86)	(0.84)	(0.84)
First year	2012.5	2012.3	2012.4	2012.4
	(3.37)	(3.17)	(3.11)	(3.02)
School decile				
n/a	0.048	0.040	0.039	0.044
	(0.213)	(0.196)	(0.194)	(0.204)
1-5	0.224	0.194	0.197	0.196
	(0.417)	(0.395)	(0.398)	(0.397)
6-8	0.363	0.371	0.399	0.368
	(0.481)	(0.483)	(0.490)	(0.482)
9-10	0.365	0.395	0.365	0.392
	(0.481)	(0.489)	(0.481)	(0.488)
Panel B. Outcomes				
Pass all courses	0.714	0.755	0.721	0.715
	(0.452)	(0.430)	(0.448)	(0.452)
Any work	0.469	0.510	0.473	0.482
	(0.499)	(0.500)	(0.499)	(0.500)
N	241,887	75,003	16,995	5,598
Percent	100	31.0	7.0	2.3

Notes: Sample characteristics at individual level. Columns 3 – 4 are not mutually exclusive. Details for categorisation are in Table 4.1. Standard deviation in parentheses. Panel B are means for outcomes in the first semester of the first year, excluding those who are injured in the first semester. In line with data use requirements, counts are randomly rounded to a number divisible by 3.

Table 4.3. The impact of injuries on student reenrolment and degree completion

	(1) Reenrol next semester	(2) Reenrol next year	(3) Complete degree in 4 years
Panel A - Year 1			
Minor injury	-0.00577***	-0.0120***	-0.00591*
	(0.00207)	(0.00277)	(0.00355)
ED	-0.0154***	-0.0252***	-0.0288***
	(0.00495)	(0.00664)	(0.00837)
Hospital	-0.0402***	-0.0522***	-0.0343**
	(0.00845)	(0.0107)	(0.0137)
Non-injured mean	0.89	0.80	0.55
N	379,791	379,791	301,011
Individuals	194,223	194,223	153,852
Schedules	129,712	129,712	106,532
Panel B - Year 2			
Minor injury	-0.00357*	-0.00332	-0.00002
	(0.00214)	(0.00289)	(0.00373)
ED	0.00335	-0.00304	-0.00267
	(0.00537)	(0.00742)	(0.0102)
Hospital	-0.0261***	-0.0268**	-0.0320**
	(0.00957)	(0.0118)	(0.0153)
Non-injured mean	0.91	0.84	0.64
N	302,580	302,580	270,672
Individuals	155,448	155,448	139,038
Schedules	165,040	165,040	149,049
Panel C - Year 3			
Minor injury	-	-	-0.000193
			(0.00332)
ED	-	-	-0.00509
			(0.00906)
Hospital	-	-	-0.0110
			(0.0144)
Non-injured mean	-	-	0.67
N	-	-	269,406
Individuals			140,157
Schedules			171,246

Notes: Outcome is indicator for (1) re-enrol next semester; (2) re-enrol next year; (3) complete degree within four years. Includes controls for year, semester, sex, school, high school grade, injury in two years prior to first enrolment, and schedule fixed effects. Standard errors are clustered at the schedule level. Sample is stratified by year. Samples in column (1) and (2) exclude 2018. Column (3) sample includes students who first enrol before 2016. *** p<0.01, ** p<0.05, * p<0.1

Table 4.4. The impact of injuries on student reenrolment and degree completion, with restricted sample

	(1) Reenrol next semester	(2) Reenrol next year	(3) Complete degree in 4 years
Panel A - Year 1			
Minor injury	-0.00171	-0.00624	-0.00003
	(0.00339)	(0.00439)	(0.00602)
ED	-0.0141*	-0.0280***	-0.0251*
	(0.00770)	(0.00991)	(0.0130)
Hospital	-0.0303**	-0.0308**	-0.0325
	(0.0133)	(0.0156)	(0.0217)
N	266,037	266,037	211,653
Individuals	135,876	135,876	108,048
Schedules	100,947	100,947	82,935
Panel B - Year 2			
Minor injury	-0.00146	-0.00233	0.00432
	(0.00332)	(0.00446)	(0.00590)
ED	0.00238	0.00361	-0.00996
	(0.00818)	(0.0110)	(0.0150)
Hospital	-0.0277*	-0.0460***	-0.0333
	(0.0147)	(0.0175)	(0.0234)
N	214,524	214,524	192,213
Individuals	110,133	110,133	98,676
Schedules	124,576	124,576	112,606
Panel C - Year 3			
Minor injury	-	-	0.00329
			(0.00489)
ED	-	-	0.00101
			(0.0140)
Hospital	-	-	0.0180
			(0.0211)
		-	
N	-	-	191,865
Individuals			99,753
Schedules			127,160

Notes: Sample is restricted to students with a maximum of two injuries in five years prior to first enrolment. Outcome is indicator for (1) re-enrol next semester; (2) re-enrol next year; (3) complete degree within four years. Includes controls for year, semester, sex, school, high school grade, injury in two years prior to first enrolment, and schedule fixed effects. Standard errors are clustered at the schedule level. Sample is stratified by year. Samples in column (1) and (2) exclude 2018. Column (3) sample includes students who first enrol before 2016. *** p<0.01, ** p<0.05, * p<0.1

Table 4.5. The impact of injuries on re-enrolment, by semester

	Reenrol next semester	Reenrol next year	Complete in 4 years
Year 1 Semester 1			
Minor injury	-0.00230	-0.0128***	-0.00772*
	(0.00193)	(0.00377)	(0.00445)
ED	-0.0155***	-0.0359***	-0.0323***
	(0.00490)	(0.00927)	(0.0114)
Hospital	-0.0441***	-0.0615***	-0.0318*
	(0.0103)	(0.0151)	(0.0190)
Non-injured mean	0.96	0.80	0.54
N	194,223	194,223	153,849
Year 1 Semester 2			
Minor injury	-0.00978**	-0.0105**	-0.00359
	(0.00396)	(0.00410)	(0.00571)
ED	-0.0167*	-0.0135	-0.0239*
	(0.00921)	(0.00957)	(0.0124)
Hospital	-0.0353**	-0.0446***	-0.0440**
	(0.0143)	(0.0152)	(0.0205)
Non-injured mean	0.83	0.81	0.56
N	185,571	185,571	147,165
Year 2 Semester 1			
Minor injury	-0.00382*	-0.000637	0.00130
	(0.00221)	(0.00400)	(0.00540)
ED	0.00431	0.00767	0.0179
	(0.00496)	(0.00992)	(0.0129)
Hospital	-0.0196*	-0.00394	-0.000547
	(0.0105)	(0.0164)	(0.0213)
Non-injured mean	0.96	0.84	0.64
N	152,856	152,856	136,728
Year 2 Semester 2			
Minor injury	-0.00301	-0.00585	-0.00113
	(0.00389)	(0.00415)	(0.00509)
ED	-0.000691	-0.0197*	-0.0264
	(0.0105)	(0.0110)	(0.0163)
Hospital	-0.0293*	-0.0486***	-0.0623***
	(0.0160)	(0.0172)	(0.0222)
Non-injured mean	0.86	0.84	0.65
N	149,721	149,721	133,947

Year 3 Semester 1			
Minor injury	-0.00297	-	0.00184
	(0.00231)		(0.00476)
ED	-0.00606	-	0.00004
	(0.00676)		(0.0130)
Hospital	-0.0289**	-	-0.0190
	(0.0115)		(0.0212)
Non-injured mean	0.97	-	0.67
N	135,315	135,315	135,315
Year 3 Semester 2			
Minor injury	-	-	-0.000610
			(0.00456)
ED	-	-	-0.00803
			(0.0128)
Hospital	-	-	-0.00008
			(0.0193)
Non-injured mean	-	-	0.67
N	-	-	134,094

Notes: Includes controls for year, sex, school, high school grade, injury in two years prior to first enrolment, and schedule fixed effects. Standard errors are clustered at the schedule level. Sample is stratified by year and semester of study. Samples in column (1) and (2) exclude 2018. Column (3) sample is where first year at university is before 2016. *** p<0.01, ** p<0.05, * p<0.1

Table 4.6. The impact of injury timing on student reenrolment and degree completion

	(1) Reenrol next semester	(2) Reenrol next year	(3) Complete degree in 4 years
Panel A - Year 1			
Minor injury × Term	-0.00401*	-0.0110***	-0.00475
	(0.00222)	(0.00312)	(0.00403)
Minor injury × Exam	-0.0136***	-0.0165***	-0.0111
	(0.00477)	(0.00626)	(0.00833)
ED × Term	-0.0160***	-0.0239***	-0.0307***
	(0.00542)	(0.00724)	(0.00926)
ED × Exam	-0.0118	-0.0327*	-0.0182
	(0.0130)	(0.0169)	(0.0211)
Hospital × Term	-0.0352***	-0.0521***	-0.0179
	(0.00925)	(0.0119)	(0.0145)
Hospital × Exam	-0.0647***	-0.0525**	-0.115***
	(0.0210)	(0.0252)	(0.0359)
Non-injured mean	0.89	0.80	0.55
N	379,791	379,791	301,011
Panel B - Year 2			
Minor injury × Term	-0.00402*	-0.00418	0.00147
	(0.00234)	(0.00308)	(0.00400)
Minor injury × Exam	-0.00152	0.000600	-0.00692
	(0.00460)	(0.00633)	(0.00823)
ED × Term	0.00468	-0.00339	-0.00154
	(0.00578)	(0.00796)	(0.0108)
ED × Exam	-0.00495	-0.000958	-0.00951
	(0.0149)	(0.0199)	(0.0259)
Hospital × Term	-0.0192*	-0.0185	-0.0190
	(0.0104)	(0.0127)	(0.0159)
Hospital × Exam	-0.0602**	-0.0673**	-0.0988**
	(0.0260)	(0.0305)	(0.0405)
Non-injured mean	0.91	0.84	0.64
N	302,580	302,580	270,672
Panel C - Year 3			
Minor injury × Term	-	-	0.00171
			(0.00370)
Minor injury × Exam	-	-	-0.0110
			(0.00757)
ED × Term	-	-	-0.00411
			(0.0103)
ED × Exam	-	-	-0.00880
			(0.0235)
Hospital × Term	-	-	-0.0201
			(0.0163)
Hospital × Exam	-	-	0.00187
			(0.0304)
Non-injured mean	-	-	0.67
N	-	-	269,406

Notes: Outcome is indicator for (1) re-enrol next semester; (2) re-enrol next year; (3) complete degree within four years. Includes controls for year, semester, sex, school, high school grade, injury in two years prior to first enrolment, and schedule fixed effects. Standard errors are clustered at the schedule level. Sample is stratified by year. Samples in column (1) and (2) exclude 2018. Column (3) sample includes students who first enrol before 2016. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4.7. Most common injuries

	N	Percent
Head	8,475	-
Concussion	3,825	45
Soft tissue	1,806	21
Upper	32,235	-
Sprain	15,393	48
Fracture/Dislocation	3,561	11
Lower	53,913	-
Sprain	35,187	65
Fracture/Dislocation	1,956	4
Back	22,188	-
Sprain	19,797	89
Face	11,448	-
Soft tissue	4,545	40
Tooth injury	2,790	24
Other	9,513	-
Soft tissue	3,978	42
Sprain	1,443	15

Table 4.8. The impact of injury location on student re-enrolment and degree completion

	(1) Reenrol next semester	(2) Reenrol next year	(3) Complete degree in 4 years
Panel A - Year 1			
Head	-0.0116*	-0.0237***	-0.0103
	(0.00676)	(0.00855)	(0.0118)
Upper	-0.00986***	-0.0230***	-0.0189***
	(0.00353)	(0.00478)	(0.00609)
Lower	-0.00101	-0.00585	-0.000139
	(0.00271)	(0.00362)	(0.00523)
Back	-0.0137***	-0.0198***	-0.00579
	(0.00488)	(0.00605)	(0.00755)
Face	-0.00926*	-0.0115	-0.0147
	(0.00556)	(0.00721)	(0.0105)
Other	-0.0219***	-0.0196**	-0.0199*
	(0.00653)	(0.00797)	(0.0114)
Non-injured mean	0.89	0.80	0.55
N	379,791	379,791	301,011
Panel B - Year 2			
Head	-0.0102	-0.00803	-0.0197
	(0.00795)	(0.00962)	(0.0137)
Upper	-0.00571	-0.00369	-0.00230
	(0.00384)	(0.00481)	(0.00664)
Lower	0.000174	-0.00449	0.00299
	(0.00283)	(0.00383)	(0.00478)
Back	-0.00922**	-0.0107*	-0.00567
	(0.00451)	(0.00555)	(0.00722)
Face	0.00951	0.00606	-0.00102
	(0.00628)	(0.00826)	(0.0110)
Other	-0.00843	-0.00589	-0.0130
	(0.00674)	(0.00861)	(0.0112)
Non-injured mean	0.91	0.84	0.64
N	302,580	302,580	270,672
Panel C - Year 3			
Head	-	-	-0.0236*
			(0.0128)
Upper	-	-	0.00210
			(0.00580)
Lower	-	-	-0.00308
			(0.00454)
Back	-	-	0.00229
			(0.00589)
Face	-	-	0.00846
			(0.00996)
Other	-	-	-0.00323
			(0.00998)
Non-injured mean	-	-	0.67
N	-	-	269,406

Notes: Outcome is indicator for (1) re-enrol next semester; (2) re-enrol next year; (3) complete degree within four years. Includes controls for year, semester, sex, school, high school grade, injury in two years prior to first enrolment, and schedule fixed effects. Standard errors are clustered at the schedule level. Sample is stratified by year. Samples in column (1) and (2) exclude 2018. Column (3) sample includes students who first enrol before 2016. *** p<0.01, ** p<0.05, * p<0.1

Table 4.9. Impact of injury on passing all courses, by model specification

Pass all	(1) Schedule FE	(2) Individual FE
Minor injury	-0.00347*	-0.00454***
	(0.00199)	(0.00138)
ED	-0.0320***	-0.0129***
	(0.00473)	(0.00341)
Hospital	-0.0612***	-0.0351***
	(0.00741)	(0.00543)
Schedule FE	Y	N
Individual FE	N	Y
N	1,053,165	1,053,165

Notes: Outcome is indicator for passing all courses in semester. Column (1) includes controls for year, year of study by semester, sex, school attended, high school grade, injured in high school, total EFTS taken and schedule fixed effects. Column (2) replaces schedule fixed effects with individual fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Table 4.10. Impact of injury on passing all courses, by year

Pass all	Year 1	Year 2	Year 3
Minor injury	-0.00706**	-0.000686	-0.00452*
	(0.00344)	(0.00298)	(0.00267)
ED	-0.0438***	-0.0213**	-0.00440
	(0.00678)	(0.00882)	(0.00786)
Hospital	-0.0761***	-0.0338***	-0.0450***
	(0.0112)	(0.0126)	(0.0137)
N	420,318	333,861	298,986

Notes: Outcome is indicator for passing all courses in semester. Sample is stratified by year of study. Includes controls for year, semester, number of EFTS taken, and individual fixed effects. Standard errors are clustered at the individual level. *** p<0.01, ** p<0.05, * p<0.1

Table 4.11. Impact of term- or exam-time injury on passing all courses

Pass all	(1)
Minor injury × Term	-0.00406***
	(0.00150)
Minor injury × Exam	-0.00587**
	(0.00297)
ED × Term	-0.0110***
	(0.00370)
ED × Exam	-0.0231**
	(0.00911)
Hospital × Term	-0.0374***
	(0.00599)
Hospital × Exam	-0.0297**
	(0.0133)
Non-injured mean	0.76
N	1,053,165
Individuals	241,890

Notes: Outcome is indicator for passing all courses in the semester. Term is indicator for injured during term time. Exam is indicator for injured during exam time. Includes controls for year, year of study by semester, total number of EFTS and individual fixed effects. Standard errors are clustered at the individual level. *** p<0.01, ** p<0.05, * p<0.1

Table 4.12. Impact of injury location on passing all courses

Pass all	(1)
Head	-0.0107**
	(0.00453)
Upper	-0.00676***
	(0.00235)
Lower	-0.00654***
	(0.00184)
Back	-0.00121
	(0.00265)
Face	-0.00448
	(0.00371)
Other	-0.0110***
	(0.00409)
Non-injured mean	0.76
N	1,053,165
Individuals	241,890

Notes: Outcome is indicator for passing all courses in the semester. Indicators for injured body part are not mutually exclusive. Includes controls for year, year of study by semester, number of EFTS and individual fixed effects. Standard errors are clustered at the individual level. *** p<0.01, ** p<0.05, * p<0.1

Table 4.13. Impact of injury location and severity on passing all courses

Pass all	(1)
Head × ACC claim	-0.00831
	(0.00555)
Head × ED	-0.00209
	(0.00905)
Head × Hospital	-0.0397***
	(0.0139)
Lower × ACC claim	-0.00374*
	(0.00193)
Lower × ED	-0.0216***
	(0.00610)
Lower × Hospital	-0.0512***
	(0.0134)
Upper × ACC claim	-0.00352
	(0.00256)
Upper × ED	-0.0172***
	(0.00619)
Upper × Hospital	-0.0231*
	(0.0121)
Back × ACC claim	-0.000866
	(0.00271)
Back × ED	0.000485
	(0.0133)
Back × Hospital	-0.0336
	(0.0238)
Face × ACC claim	-0.00844**
	(0.00395)
Face × ED	0.0169
	(0.0119)
Face × Hospital	0.0321
	(0.0216)
Other × ACC claim	-0.00680
	(0.00462)
Other × ED	-0.000883
	(0.00861)
Other × Hospital	-0.0351***
	(0.00812)
Non-injured mean	0.76
N	1,053,165
Individuals	241,890

Notes: Outcome is indicator for passing all courses in the semester. Indicators for injured body part are not mutually exclusive. Includes controls for year, year of study by semester, number of EFTS and individual fixed effects. Standard errors are clustered at the individual level. *** p<0.01, ** p<0.05, * p<0.1

Table 4.14. Impact of sport-related injuries on passing all courses

Pass all	(1)
Panel A	
Minor injury	-0.00255
	(0.00191)
Minor injury × Sport	-0.00343
	(0.00252)
ED	-0.0131***
	(0.00438)
ED × Sport	0.000865
	(0.00692)
Hospital	-0.0400***
	(0.00646)
Hospital × Sport	0.0148
	(0.0120)
N	1,053,165
Individuals	241,890
Panel B	
Minor injury	-0.00397***
	(0.00140)
Minor injury × Road	-0.0159*
	(0.00854)
ED	-0.0132***
	(0.00352)
ED × Road	0.00689
	(0.0156)
Hospital	-0.0337***
	(0.00566)
Hospital × Road	-0.0348
	(0.0223)
N	1,053,165
Individuals	241,890

Notes: Outcome is indicator for passing all courses in the semester. Includes controls for year, year of study by semester, number of EFTS and individual fixed effects. Standard errors are clustered at the individual level. *** p<0.01, ** p<0.05, * p<0.1

Table 4.15. The impact of injuries on wages during semester

	(1) >$1000	(2) >$2000	(3) >$3000	(4) >$4000
Panel A				
Minor injury	0.000707	0.000425	-0.00100	-0.000846
	(0.00142)	(0.00134)	(0.00125)	(0.00108)
ED	-0.00728**	-0.00822***	-0.00659**	-0.00404*
	(0.00327)	(0.00300)	(0.00272)	(0.00238)
Hospital	-0.0193***	-0.0284***	-0.0269***	-0.0167***
	(0.00524)	(0.00487)	(0.00431)	(0.00378)
Non-injured mean	0.42	0.32	0.22	0.14
N	1,053,165	1,053,165	1,053,165	1,053,165
Individuals	241,890	241,890	241,890	241,890

Notes: Outcome is indicator for earning over each dollar amount within the semester. OLS includes controls for year, year of study by semester, total EFTS and individual fixed effects. Standard errors are clustered at the individual level.*** p<0.01, ** p<0.05, * p<0.1

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