Effect of Campus Shootings on Academic Achievement: Examination of 2014 Isla Vista Killings[*]

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Abstract

Since 1979, the frequency of school-related gun violence has been consistently increasing with growing concerns about the impact of such events on surviving students. This paper specifically examines 2014 Isla Vista Killings occurred near UC Santa Barbara (UCSB). A student-level data containing college admissions records from four different UC campuses are used to analyze the impact of shooting on academic achievement of students on campus. Measures such as GPA, dropout rate, and percentage of failed classes (having a C or below) are used to assess the academic achievement. Through use of fixed effects model, synthetic control method, and difference-in-difference design, we find that the shooting incident caused grade inflation in UC Santa Barbara, but academic achievement of UC Santa Barbara students declined in the following quarters. We also discover that certain UC Santa Barbara students who are more likely to have close personal relationships to those who were killed or injured during this incident, demonstrated a minor decrease in academic achievements in Spring 2014 quarter relative to other UC Santa Barbara students, but their academic achievements improved in the following quarters.

1 Introduction

In this research paper, the impact of campus shooting on surviving students is examined and how students react after experiencing traumatic events. The foundation of this paper is built on a paper written by Lin (2019) and the primary goal of this paper is to advance Lin (2019)'s findings through repeating some of his research methods to verify the findings but also analyze the the impact of shooting more in depth. For example, a linear fixed effect regression model is used to control for individual characteristics that don't vary over time that could impact or bias the outcome variables. The main assumption for using this model is that variables have fixed effect relationships over time. Then, synthetic control method is used, where assumption regarding to fixed effect relationships is no longer needed. The counterfactual of UC Santa Barbara is estimated by using synthetic weights for other three UC campuses (Berkeley, Davis, and Riverside) to create synthetic UC Santa Barbara. This synthetic UC Santa Barbara resembles pre-intervention characteristics of UC Santa Barbara. We then see if results from synthetic control is similar to what we get from fixed effect model. In addition to analyzing the overall effect of shooting, we want to allow some heterogeneity of the effect by examining two subgroups within UC Santa Barbara using difference-in-difference estimation. The two subgroups used in this paper are slightly different from those used by Lin (2019). This paper has chosen two groups of impacted students that are more likely to have closer and personal relationships to those who were killed and injured from the shooting. A smaller class size is used (a class size of $\leqslant 20$) for the first subgroup and freshman seminar classes are used instead of looking at impacted females for the second subgroup.

Section 2 briefly describes the background of 2014 Isla Vista Killings. Section 3 explores various literature related to school shootings and psychiatric effects that individuals suffer after experiencing a traumatic event. Then, section 4 delves into describing the data used for analyzing this incident. Section 5 estimates the causal effect of shooting by comparing UC Santa Barbara to other campuses by using fixed effect model and synthetic control method. Then, section 6 allows heterogeneity of the effect within UC Santa Barbara by analyzing some impacted subgroups through difference-in-difference estimation. The final section includes conclusions and some limitations of this research.

2 Background

Serving more than 280,000 students and 227,000 employees in California, UC system first began its operation in 1869. The UC system is operated by 10 campuses - Berkeley, Davis, Irvine, Los Angeles, Merced, Riverside, San Diego, San Francisco, Santa Barbara, and Santa Cruz. In particular, UC Santa Barbara is a large public research institution with over 20,000 undergraduate students and it is the sixth largest among UC campuses with the undergraduate acceptance rate of 32% in 2019[1]. Part of the Santa Barbara County, Isla Vista is a small community located next to UC Santa Barbara main campus and approximately half of the residents are comprised of UC Santa Barbara students and staff [2].

The frequency of school shootings has been consistently rising since 1979. In the 20th century, 55 people were killed and 260 people were injured from different mass school shootings, involving 25 shooters in total[3]. Also, after the Columbine High School Massacre in 1999, the fear towards school shooting has been escalating consistently. The rising number of fatal school shootings from 1990 to 2018 is demonstrated in Figure 9. Especially the year of 2006 in shown in Figure 9 marked a sharp increase in the number of fatal school shootings. After 2006, a consistent increasing trend of number of fatal shootings was observed. Even though the number of school shootings has been consistently rising, there has been a lack of prevalence and clarity in occurrence of school shootings. The United States Department of Education and the United States Secret Service reported that the chance of a student dying from a school-related homicide was "no greater than one in 1 million (Vossekuil, Fein, Reddy, Borum, and Modzeleski, 2002). Because of such underestimated views of the impact of school shooting, not much have been done in examining the impact of such incidents.

2014 Isla Vista Killings is a recent example of a school-related homicide that occurred on a college campus. On May 23, 2014, a 22-year old male UC Santa Barbara student named Elliot Rodger killed six and injured 14 people near UC Santa Barbara main campus before committing a suicide. Prior to the shooting, Elliot uploaded a video and a 141-page manifesto called *The Twisted World: The Story of Elliot Rodger*. This manifesto specifically mentions that this shooting was targeted towards women, as he desired to punish women for rejecting him. At the same time, he also wanted to punish other males

[1]How Does University of California–Santa Barbara Rank Among America's Best Colleges?" U.S. News amp; World Report, U.S. Newsamp; World Report, www.usnews.com/best-colleges/university-of-california-santa-barbara-1320.

[2]"Isla Vista." UC Santa Barbara, The Regents of the University of California, www.sa.UC Santa Barbara.edu/parents/student-activities-campus-life-1/student-activities-campus-life/isla-vista.

[3]"Rapid Rise in Mass School Shootings in the United States, Study Shows." ScienceDaily, ScienceDaily, 19 Apr. 2018, www.sciencedaily.com/releases/2018/04/180419131025.htm.

because they were engaged in relationships with females that he failed to be engaged in[4]. Elliot was half White, half Asian and he opposed interracial dating and uploaded posts on the online forum where expressed his detest for other races[5]. He felt that his mix race of White and Asian made him superior compared to others in his self-proclaimed ideal world. However, unlike what he had imagined himself to be in his ideal world, he was socially isolated in reality and was incapable of finding a girlfriend to have a sexual intercourse with. He first killed three of his roommates in his apartment[6], who were all Asians. Then, he drove to the sorority house, which he thought it was the hottest sorority of UCSB[7], and killed two sorority sisters. Afterwards, he drove around UC Santa Barbara area and resulted in additional death and injuries. Right after committing a homicide, Elliott killed himself inside his vehicle. This resulted in seven deaths (including Elliot himself) and 13 injuries[8]. All of the six individuals who were killed and nine individuals who were injured were UC Santa Barbara students. After this incident occurred, all the classes at UC Santa Barbara were cancelled and memorial service was carried out to memorialize those who were killed from this incident[9]. Then, the courses at UC Santa Barbara were resumed afterwards until the end of Spring 2014 quarter.

This shooting demonstrates characteristics of a modern school-related homicide. The attack involved use of sophisticated weapon, a gun in this case, and the incident was carried due to dissatisfaction and anger towards the society. However, what makes it different from other school shootings is that the shooting did not occur at a single particular place on campus, but at various locations off-campus. Still, the targets of this shooting were students and the incident occurred during the time academic quarter. Thus, it can be said that this incident resembles many other school shootings that occurred between 1990 to 2018.

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[4]Rodger, Elliot (n.d.). the Twisted World: The Story of Elliot Rodger (PDF). Archived (PDF) from the original on May 25, 2014. Retrieved June 14, 2014 – via Document Cloud.org.

[5]Glasstetter, Josh (May 24, 2014). "Elliot Rodger, Isla Vista Shooting Suspect, Posted Racist Messages on Misogynistic Website". Hatewatch. Southern Poverty Law Center. Archived from the original on August 14, 2015. Retrieved February 22, 2016.

[6]"Isla Vista Mass Murder – May 23, 2014 – Investigative Summary" (PDF). Santa Barbara County Sheriff's Office. February 18, 2015. Archived from the original (PDF) on February 20, 2015. Retrieved February 19, 2015.

[7]Beekman, Daniel (May 26, 2014). "Elliot Rodger wrote manifesto on his hate for women and his vindictive scheme prior to deadly rampage". New York Daily News. Archived from the original on May 26, 2014. Retrieved June 30, 2014.

[8]Ellis, Ralph; Sidner, Sara (May 27, 2014). "Deadly California rampage: Chilling video, but no match for reality". CNN. Archived from the original on June 7, 2014. Retrieved June 13, 2014.

[9]Feldman, Dana (May 26, 2014). "Father blames government 'idiots' as California town mourns killings". Yahoo! News. Reuters. Archived from the original on May 27, 2014. Retrieved July 2, 2014.

3 Literature Review

There is a considerable amount of research done by other economists and psychiatrists regarding to side effects that arise after individuals experience traumatic events. Some specific research was done to examine the impact of school shootings in primary and secondary schools. However, there's a lack of research on examining the impact of shootings on college campus and many use aggregate level data to conduct the research. In order to address these issues, this paper investigates a specific campus shooting incident, the 2014 Isla Vista Shootings, using a student-level data to examine the impact of such traumatic event on surviving students.

There are psychiatric effects that affect surviving individuals after experiencing the distressing events. Gale and Resnick (2005) suggested that those who experienced human-made disasters, such as terrorist attacks, were more severely impacted negatively compared to those who experienced other types of disasters. This result was demonstrated by higher rates of post-traumatic stress disorder (PTSD) for the population that experienced human-made disasters compared to the population that experienced natural disasters. Another study by Blanchard et al. (2005) also exhibited a similar result. The college-aged individuals (typically between the age of 18 to 24) were more vulnerable to PTSD a year after the 9/11 terror attack. Thus, it seems plausible to hypothesize that there would be negative impacts of school shooting on surviving students for 2014 Isla Vista shooting incident. Also, the effect of such traumatic events to individuals in this particular age range (age of 18 to 24, a typical age range for college students) seems to be quite crucial and individuals at this particular range of age seem to be mentally susceptible to such events.

Delving specifically into the literature that examines school shootings, most literature tend to focus on the mass shooting incidents that occurred in primary and secondary schools. Gershenson and Tekin (2018) examined elementary school students in particular, and noticed a decrease in reading proficiency levels following traumatic events. Another research from Beland and Kim (2016) measured effects on high school students after several school shootings around the area by observing high school enrollment rates and math and reading scores. They have noticed a significant decline in ninth grade enrollment rates and math and reading scores. An empirical research on high school students' matriculation exam scores by Poutvaara and Ropponen (2010) also demonstrated similar results. The difference between test scores before and after high school matriculation exams were lower following the school shooting

incident. Something interesting that they've noticed was that the average score remained the same for females, but only resulted in decrease in the average score of males.

Some research attempted to explain the reasoning behind outcomes for individuals after experiencing traumatic event. Campbell and Schwarz (1996) observed higher rate of mental disorders, such as depression, after individuals were exposed to some violent traumatic experience. In particular, the study showed that children and young adults were more likely to have issues with their mental health compared to adults. Similarly, Fergusson and Woodward (2002) noted that there's an increased risk for adverse psycho-social outcomes in the transitory stage of entering adulthood for children who are experiencing depression during their adolescence period. Ding et al. (2009) noticed a negative relationship between academic achievement and psychological trauma.

Cornell (2006) noted that compared to other type of violence that leads to death of students, school shootings incidents draw intense amount of attention and form an inflated perception of danger. For example, following the Columbine High School Shooting that result in deaths of 12 students and one teacher, Gallup (1999) discovered that more than one out of three high school students felt that their school were "potentially violent enough to cause a situation such as the one that occurred in Columbine High School". A study by Anderson (2001) pointed out the irony of inflated perception of danger. In the year when Columbine High School Shooting occurred, 17 students were killed on campus, while more than 2,500 individuals between age of 5 to 19 were killed in accidents that occurred outside of campus. Such statistics further emphasize that the impact of school shootings are quite detrimental and impactful to surviving students and the school community. However, it is important to point out that such results are only applicable to primary and secondary school students.

In terms of examining the side effects that arise after experiencing traumatic events and the impacts of school shooting, a significant amount of research is being done, as evidenced by numerous research papers cited above. Also, seen from the publication of the Journal of School Violence, it can be said that school violence is more than just a scientific inquiry. It is being researched in an extensive amount that it can be recognized as a field of study (Furlong, Morrison, Cornell, Skiba, 2004). However, many studies researching about traumatic effects on the population often used macro-level data, such as class-level, school-level, or national-level. The advantage of this research on 2014 Isla Vista Shootings incident is that it utilizes micro-level data using administrative UC enrollment database from four UCs: Berkeley,

Davis, Riverside, and Santa Barbara. The micro-level data is better than school-level or national-level data when it comes to interpreting results for local population being observed. Also, many studies regarding to school violence are mainly done for school shooting incidents in primary and secondary schools, not in college campus. Thus, this research advances the field in a way that it examines shooting incident on college campus and observes the effect of traumatic events on surviving college students.

4   Data

4.1   UC Enrollment Database

This paper primarily uses administrative UC enrollment database, containing over 8 million records of students who were enrolled in four UC campuses - Berkeley, Davis, Riverside, and Santa Barbara from 2011 to 2018. The data was collected by the UC office of the President. The student-level data contains anonymized unique identification (ID) for each students, basic college application information (SAT / adjusted ACT scores, high school GPA, transfer GPA, admission type, etc.), UC GPA, course information (course number, course department, course term, course year, etc.), race (Polynesian, Chinese/Chinese-American, Black/African American, etc.), and gender. The indicators for killed and injured students are also included. However, out of 13 injured victims, six of them were not enrolled in UC Santa Barbara, so the data for these individuals were not observed in this data set.

Our panel data is a student-level data observed in each quarters between 2011 to 2018. For the purpose of analysis, all the summer quarters are removed for all campuses and the data for Winter 2014 quarter, which is the quarter before the shooting incident, was not recorded for UC Santa Barbara in the database. Additionally, the courses taken by students who were killed during 2014 Isla Vista Killings were not observed in Spring 2014 quarter, as all of these six students immediately received posthumous degrees. Because Berkeley uses semester system instead of quarter system, the data for Spring semester of Berkeley was replicated to represent hypothetical Winter quarter for Berkeley campus.

The fixed effect model is used commonly to analyze panel data to estimate the impact of variables that vary over time. The summary statistics of the selected variables used in fixed effect model is shown in Table 1. Each observation indicates course type and course grade taken by a student for each quarter. It also contains information about the characteristics of each students, such as race, gender, and high

school GPA. The control group indicates students in other three UC campuses (Berkeley, Davis, and Riverside) and the treatment group indicates students at UC Santa Barbara. From Table 1, we notice that control group offers about 20% more STEM courses than treatment group. Also, we notice that treatment group has more students with White background and have slightly higher SAT/adjusted SAT scores compared to that of control group. The other variables of control and treatment group exhibit extremely similar values. Overall, we can see that there is no statistically significant differences between mean values of control group (UC Santa Barbara) and that of treatment group (UC Berkeley, UC Davis, and UC Riverside). In addition to applying fixed effect model to this data set, we also use synthetic control method to use synthetic weights to estimate counterfactual of UC Santa Barbara by using other three UC campuses included in control group.

Because UC Santa Barbara is a large public institution with over 20,000 undergraduate students[10], the effect of the shooting incident is difficult to be impacted uniformly across all students and the overall impact might be not significant. It is almost impossible for every student to have personal connections or interactions with students who were killed or injured from the incident. So, in addition to observing aggregate effect of the shooting, we are seeing if there's an effect of shooting on two subgroups of students on UC Santa Barbara. These two subgroups were chosen to be composed of students who are more likely to have built some personal relationships with students who were killed or injured in 2014 Isla Vista Killings. The first subgroup includes individuals who took classes with students who were either killed or injured during the incident in a small class with approximately 20 students or less, prior to Spring 2014 quarter. Another subgroup contains those who took freshman seminar classes with killed or injured students from the attack prior to Spring 2014 quarter.

5   Estimation of Overall Casual Effect of Shooting

Before we look into examining UC Santa Barbara students, we first want to see the impact of shooting on UC Santa Barbara campus at an aggregate level by comparing with other UC campuses included in this data set. To estimate the effect, fixed effect model is used to compare differences in academic achievement of treatment campus (UC Santa Barbara) and control campus (UC Berkeley, UC Davis, and UC Riverside). This model is used to control for individual characteristics that doesn't vary over time

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[10]How Does University of California–Santa Barbara Rank Among America's Best Colleges?" U.S. News amp; World Report, U.S. Newsamp; World Report, www.usnews.com/best-colleges/university-of-california-santa-barbara-1320.

that could impact or bias the outcome variables, with assumption that fixed effect relationships for variables hold over time. Additional time effects are included to also control for unobserved characteristics that varies over time. However, issue is that these effects could vary over time and change the results. So, synthetic control method is used to allow for these effects to vary over time by applying synthetic weights to other three UC campuses to best simulate UC Santa Barbara during pre-intervention period before shooting. The difference between actual UC Santa Barbara and synthetic UC Santa Barbara is used to examine the overall effect of shooting on academic achievement of students. For the purpose of analysis, we use 8 periods before $(T_0 - 8)$ and 8 periods after $(T_0 + 8)$ Spring 2014 quarter when shooting occurred, which is somewhere in between two to three years before and after shooting. Such time frame is chosen because these students who were killed or injured in the incident were mostly sophomores and juniors who are likely to graduate within two to three years. After they graduate, we won't be able to observe them in our data set, so it makes it difficult to interpret results if the time frame stretches out too far from Spring 2014 quarter. For aggregate effect, the hypothesis is that in period 0, which refers to Spring 2014 quarter when shooting occurred, students at UC Santa Barbara are likely to demonstrate lower levels of academic achievements relative to other UC campuses in this database and this pattern sill continue in the following quarters, as it takes time for students to recover from such traumatic event.

5.1 Fixed Effect Model

In order to measure the aggregate effects of shooting for a single treatment group, fixed effect model was used to measure the impact of campus shooting on UC Santa Barbara. This impact is measured by comparing academic achievements shown by students in treatment and control campuses. Using the panel data, I examined 8 quarters before and after shooting incident in Spring 2014 quarter. The following fixed effect model is implemented:

$$Y_{it} = \delta_t + \beta(UCSB_i * SP14_t) + \gamma X_{it} + \varepsilon_{it} \tag{1}$$

where Y_{it} estimates academic achievement of interest, such as end of quarter GPA based on 4.00 scale, an indicator for failed classes (lower than C in any course), or an indicator for dropouts for individual i at time t. δ_t is the time fixed effect that includes 8 quarter periods before and after the shooting. β measures the impact of campus shooting on academic achievement of UC Santa Barbara students in the quarter when shooting occurred. $UCSB_i$ is an indicator for UC Santa Barbara students (1 if individual

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i is a student at UC Santa Barbara) and $SP14_t$ is an indicator for Spring 2014 quarter. X_{it} is a vector of student characteristics that varies in time, such as percentage of stem classes and average number of units taken by an individual i at time t. Finally, ε_{it} represents characteristics of individual i at time t that are not captured by predictors and it is assumed to be orthogonal to other independent variables. This model is estimated by OLS over students who were enrolled in the four UC campuses in data set 8 quarters before and ater the shooting and the errors are robust [11].

In Table 2, the estimate of variable of interest, β is statistically significant at 99% level for all dependent variables (end of quarter GPA, dropout rate, and percentage of failed classes). UC Santa Barbara students on average had an end of quarter GPA of 0.020 GPA point higher than non-UC Santa Barbara students in Spring 2014 quarter, keeping other variables constant. Similarly, UC Santa Barbara students received 0.6% less failing grades (any course grade of C or below) than non-UC Santa Barbara students in Spring 2014 quarter. However, unlike higher academic achievement for UC Santa Barbara students in this quarter, dropout rate for UC Santa Barbara students was 0.5% higher relative to that or non-UC Santa Barbara students. One explanation that can explain this result is that there was a grade inflation on UC Santa Barbara in general to mediate the effect of such a disastrous event happening on campus. However, perhaps the shock was too much for some students to handle that didn't stop them to drop out of college.

In Figure 1, the estimated effect of shooting on academic achievement for UC Santa Barbara and non-UC Santa Barbara students are plotted for 6 quarters before and after the shooting to examine closely around quarter when shooting occurred, indicated as quarter 0 in these plots. For Figure 1(a), UC Santa Barbara students demonstrated particularly higher end of quarter GPA in quarter 0 compared to any other periods prior to shooting. Then, it demonstrated a decline in end of quarter GPA relative to non-UC Santa Barbara students in the subsequent quarters. We also notice that in UC Santa Barbara, the percentage of failing courses is increasing after quarter 0 relative to that in other UC campuses in control group. For Figure 1(c), the presence of strong seasonality every spring quarter is difficult to interpret, but it seems fair to say that dropout rate didn't seem to change drastically before and after shooting, although the dropout rate in treatment group is higher than that in control group in quarter 0. Because dropping out of college is such a big decision to make, perhaps that's why dropout rate didn't increase or decrease significantly after the shooting.

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[11]The OLS estimation is conducted through use of *felm* function in the *lfe* package in R, version 2.8-2.

5.2 Synthetic Control Method

In addition to using fixed effect model, synthetic control method (Abadie and Gardeazabal, 2003 ; Abadie et al., 2010) is used to estimate the effect of 2014 Isla Vista Shooting at an aggregate level. Because UC campuses operate under the same UC system and as seen by how differences between UC Santa Barbara and other three campuses in Table 1 are statistically insignificant, using synthetic weight combination of UC Berkeley, UC Davis, and UC Riverside seem to be a reasonable choice to estimate the counterfactual of UC Santa Barbara. It will be useful to compare the outcomes between actual UC Santa Barbara and synthetic UC Santa Barbara after exogenous shock.

Our panel data have $J+1$ campuses where $j = 1, 2, ..., J+1$ and they are observed over T periods, where the first T_0 periods indicate quarters before shooting. Let $j = 1$ represent our treated campus, UC Santa Barbara, which is the only campus that had campus shooting at time period T_0. So, $j = 2, ..., J+1$ represent our control campuses where shooting did not occur. Thus, we can model the treatment effect for UC Santa Barbara as the following:

$$\tau_{1t} = Y_{1t}(1) - Y_{1t}(0) \tag{2}$$

where $Y_{1t}(1)$ represents potential outcome with treatment and $Y_{1t}(0)$ represents the counterfactual, which is the potential outcome without the treatment for UC Santa Barbara at time t. So, τ_{1t}, our estimated outcome of interest, represents the difference between potential outcome with and without treatment. Because our counterfactual is not directly observed, our goal is to estimate the counterfactual after shooting at period $t = T_0$ to see what would the outcome look like for UC Santa Barbara in the absence of shooting.

As a result, our outcome of interest, τ_{jt} is estimated as:

$$\hat{\tau}_{1t} = Y_{1t}(1) - \hat{Y}_{1t}(0) \tag{3}$$

where

$$\hat{Y}_{1t}(0) = \sum_{j=2}^{J+1} w_j Y_{jt} \tag{4}$$

Our counterfactual, $Y_{1t}(0)$ is estimated by $\hat{Y}_{1t}(0)$, the weighted combination of potential comparison using synthetic weights w_j. Let the weights used to approximate our counterfactual as a $Jx1$ vector,

$\mathbf{W} = (w_2, ..., w_{J+1})'$, where each weights are non-negative values and $\sum_{j=2}^{J+1} w_j = 1$. Given a set of non-negative constants $v_1, ..., v_k$ for each k predictors, the synthetic control, $\mathbf{W}^* = (w_2^*, ..., w_{J+1})^*$ minimizes the following distance:

$$\|\mathbf{X_1} - \mathbf{X_0W}\| = (\sum_{h=1}^{k} v_h(X_{h1} - w_2 X_{h2} - ... - w_{J+1} X_{hJ+1})^2)^{1/2} \tag{5}$$

where $\mathbf{X_1}$ is a vector of pre-treatment characteristics of the treatment group and $\mathbf{X_0}$ is a vector of pre-treatment characteristics of control group. $\mathbf{V} = (v_1, ..., v_k)'$ is chosen so that synthetic control, $\mathbf{W(V)} = (w_2(\mathbf{V}), ..., w_{J+1}(\mathbf{V}))'$ minimizes the mean squared prediction error (MSPE) with respect to $Y_{1t}(0)$:

$$\sum_{t \in \tau_0} (Y_{1t} - w_2(\mathbf{V}) Y_{2t} - ... - w_{J+1}(\mathbf{V}) Y_{(J+1)t})^2 \tag{6}$$

for $\tau_0 \subseteq 1, 2, ..., T_0$, the periods before shooting.

The weights used to create synthetic control using three UC campuses (Berkeley, Davis, Riverside) is shown in Table 3[12]. By the construction of synthetic control design described above, the value of covariates of synthetic UC Santa Barbara should be very close to that of covariates of UC Santa Barbara. It is important to note that shooting occurred three weeks before Spring 2014 quarter ended, so we are interested in looking at the difference in outcome variables between actual outcomes of UC Santa Barbara and predicted synthetic UC Santa Barbara in Spring 2014 quarter.

Table 4 shows estimates of mean values of covariates under each synthetic control design. The results we get from synthetic control method in column 2, 3, and 4 seem to be close to that of UC Santa Barbara in column 1. We can notice that in general, values we get from synthetic control is a bit underestimated compared to just using an overall average with equal weights in column 5, so it mimics UC Santa Barbara as close as possible as a counterfactual. From this table, students in synthetic UC Santa Barbara is composed of slightly more transfer students than freshman admit students, slightly more females, takes more STEM courses, and has more international students with less students with white racial group.

Figure 2 demonstrates trends in academic achievement of UC Santa Barbara and synthetic UC Santa Barbara plotted over 6 periods before and after shooting to observe closely around quarter 0. Overall, these three plots demonstrate some seasonality for UC Santa Barbara. For example, all three plots

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[12]An R package *Synth* was used to find weights and run synthetic control design.

demonstrate similar trends occurring every 3 quarters for UC Santa Barbara and particularly Figure (2c) shows seasonality for synthetic UC Santa Barbara as well.

To take a closer look at the difference between our actual UC Santa Barbara and synthetic UC Santa Barbara, the difference plot is plotted by taking a difference between actual UC Santa Barbara and synthetic UC Santa Barbara for outcome variables in Figure 3. The difference in end of the quarter GPA between synthetic UC Santa Barbara and UC Santa Barbara at period 0 in Figure (3a) is about 0.06 GPA points. So, it can be said that shooting caused the end of quarter GPA to increase about 0.06 GPA points after shooting. Also, in Figure (3b), we notice that UC Santa Barbara had about 1.4% lower percentage of failing a class than synthetic UC Santa Barbara in quarter 0. These results seem to suggest that there may have been a grade inflation in the period when shooting occurred. To help students to overcome such a traumatic event where some students could have lost their closest friends, professors may have given more generous grades to students. We also notice that after period 0, there's a rising trend in end of quarter GPA for UC Santa Barbara and also declining percentage of failing a course relative to synthetic UC Santa Barbara in Figure (2a) and Figure (2b). However, similar to what we have observed for fixed effect model, there seems to be minor change in dropout rate before and after period 0. A potential explanation for such result is that dropping out is not an easy decision to make even if the grade is falling, so the impact of exogenous shock didn't impact dropout rate very much, as the difference between UC Santa Barbara and synthetic UC Santa Barbara dropout rate in period 0 is almost close to 0 as seen by figure (3c). Even after period 0, despite relatively higher percentage of receiving a failing grade on a course for UC Santa Barbara, it doesn't seem to affect the dropout rate too much.

6 Estimation of Impact on Subgroups

Now, we allow for some heterogeneity of the effect of the shooting by observing various subgroups on UC Santa Barbara campus. Two different subgroups are analyzed using difference-in-difference method to measure the impact of campus shooting on academic success for individuals associated with each subgroups. The shooting incident event is modelled as an exogenous shock. Specifically, difference-in-differences is modeled with multiple time periods, examining 8 periods before the event and 8 periods after the event. Similar to the reasoning for observing aggregate effect in section 5, students who were killed or injured in the shooting were mostly juniors and sophomores who are likely to graduate soon

within the next few years. The hypothesis is that after the shooting, individuals in both subgroups will be negatively impacted and this will lead to decrease in their academic achievement. Because many literature suggested that students' academic achievement decreased at a statistically and economically significant level after secondary school shooting, I would expect similar results to hold for college shooting as well.

6.1 Impacted Students: Class Size $\leqslant 20$

The first subgroup to be examined is a group of individuals who were enrolled in class size $\leqslant 20$ with at least one killed or injured student from the attack prior to shooting in Spring 2014 quarter. The class size of $\leqslant 20$ was chosen because many literature supports that 20 is a reasonable number to describe a small class (Blatchford, 2003b; Blatchford, Baines, Kutnick & Martin, 2001; Finn, Pannozzo & Achilles, 2003; Glass & Smith, 1979; Milesi & Gamoran, 2006). Because the class size is small, there's a higher chance for students in the class to build personal connections with their classmates. Thus, it is more likely for students in this class to have interactions with students who were killed or severely injured from the incident. The impacted student in this subgroup is defined as a student who took same class as at least one of the killed or injured student from the attack prior to Spring 2014 quarter with a class size $\leqslant 20$.

The regression model used to run the difference-in-difference analysis is the following:

$$Y_{it} = \delta_t + \beta\,(IM_i * Post_t) + \theta IM_i + \gamma X_{it} + \varepsilon_{it} \tag{7}$$

where Y_{it} indicates response variables being examined, which includes end of quarter GPA based on 4.00 scale, an indicator for individual i failing (having a C or below) in any course, or an indicator for dropouts for individual i at time t. δ_t is the time fixed effect that includes 8 quarter periods before and after the shooting. β is the estimate of interest and it measures the impact on academic achievement after the shooting. IM_i is an indicator variable for impacted students (1 if individual i is an impacted student, 0 otherwise) and $Post_t$ indicates whether it's before or after the impacted (1 if time period $t \geqslant 0$, 0 otherwise). X_{it} is a vector of permanent student characteristics, such as gender, admission type, high school GPA, and etc for individual i at time t. Finally, ε_{it} represents characteristics of individual i at time t that are not captured by the predictors and it is assumed to be orthogonal to other independent variables. Thus, this model is estimated by OLS over all UC Santa Barbara students from 2011 to 2018

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and the errors are robust [13].

Table 5 demonstrates the results from running the regression for equation (7). The estimate of interest, β is significant at 95% level for end of the year GPA and dropout and is significant at 90% level for percentage of failing a class (having a C or below in any course). On average, end of quarter GPA estimate for impacted students were 0.064 point higher after the incident than non-impacted students. Similarly, impacted students on average were estimated to fail 1.7% less classes than non-impacted students. This result makes sense, as receiving a C or below is related to end of quarter GPA. Unlike these two results that seem to demonstrate that students in this subgroup did slightly better academically after the incident, the dropout rate was higher for impacted students compared to non-impacted students. The dropout rate increased by 0.6% for these students compared to those who were not in the subgroup.

The following regression was used in order to account for effects for each quarter:

$$Y_{it} = \delta_t + \beta IM_i + \gamma X_{it} + \varepsilon_{it} \tag{8}$$

where Y_{it} estimates academic achievements, such as end of quarter GPA based on 4.00 scale, indicator for failed classes (lower than C in any course), or indicator for dropouts for individual i at time t. δ_t is the time fixed effect that includes 8 quarter periods before and after the shooting. β measures the impact of shooting on academic achievement of impacted students at t periods prior or after the attack. X_{it} and ε_{it} are same as previous specification in equation (7).

The difference-in-difference graphs in Figure 4 are demonstrating results that are contradicting to the hypothesis that academic achievements of impacted students will be negatively affected after the incident. In Figure 4(a), although the estimated average effect of shooting on impacted students end of quarter GPA decreased by 0.07 point in Spring 2014 quarter compared to that of non-impacted students, there's an overall increasing trend in academic success after period 0. Although the noise increases as period increases, still there seems to be an increasing trend in end of quarter GPA after 2014 Isla Vista Killings for impacted students relative to non-impacted students. Similar pattern is demonstrated in Figure 4(b). The estimated effect on average percentage of having a C or below in a course decreased by 1% for impacted students in class size $\leqslant 20$ relative to non-impacted students in period 0. Overall, there

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[13]The OLS estimation is conducted through use of *felm* function in the *lfe* package in R, version 2.8-2.

seem to be decreasing trend in percentage of having a C or below for impacted students compared to non-impacted students, meaning that impacted students seem to have higher percentage of receiving a passing grade after shooting relative to non-impacted students. For Figure 4(c), there's not much change in dropout rate before and after shooting, but the overall trend is that dropout rate is a decreasing trend in dropout rates after period 0. The estimated effect of shooting on average percentage of dropout rate increased by 0.3% for impacted students compared to non-impacted students at period 0.

All three difference-in-difference plots in Figure 4 seem to demonstrate the academic success of impacted students after the shooting, relative to non-impacted students. However, in the quarter when shooting occurred, the shooting negatively impacted their academic achievement. One possible explanation for the academic success is that like what we've shown in section 5, it seems that grade inflation took place in UC Santa Barbara to help students to recover from the incident. However, compared to non-impacted students, impacted students could have been harder to concentrate on studies. Then, those impacted students who remained and didn't drop out of school and remained could have slowly recover from incident it is possible that the grade inflation could've sustained for longer periods of time. Because this shooting occurred near the main campus, this shooting was real for UCSB community. Hence, the school could've encouraged professors to be more generous with assigning grades to students for periods after the shooting had occurred.

6.2   Impacted Students: Freshman Seminar

The second subgroup to be examined is a group of students who were enrolled in freshman seminar classes with at least one killed or injured student from the shooting, prior to the incident in Spring 2014 quarter. Because freshman seminars involve group activities and is designed to help students to ease into college life, students in freshman seminar classes have a higher chance to develop personal connections with injured or killed students from the incident. The impacted student for this subgroup is defined as an individual who were enrolled in a freshman seminar prior to Spring 2014 quarter with at least one killed or injured student from the incident.

Similar to equation (7), the regression model used to run the difference-in-difference analysis is the following:

$$Y_{it} = \delta_t + \beta(FSIM_i * Post_t) + \theta FSIM_i + \gamma X_{it} + \varepsilon_{it} \tag{9}$$

where Y_{it}, δ_t, $Post_t$ and ε_{it} is same as equation (7). β is the estimate of interest, which measures the average estimate of impact on academic achievement for impacted students who were enrolled in freshman seminar prior to the shooting, relative to non-impacted students. $FSIM_i$ is an indicator variable for impacted students. Just like equation (7), this model is estimated by OLS over all UC Santa Barbara students from 2011 to 2018 and the errors are robust [14]. Again, the data does not include summer quarters and winter 2014 quarter is missing.

In Table 6, the estimate of interest, β is statistically significant at 95% level for end of the year GPA and percentage of having a course grade C or below. However, β was statistically insignificant for dropout rate. An impacted student on average had an end of quarter GPA of 0.303 point higher than non-impacted students after the incident. Similarly, impacted students failed 0.7% less than those who were not impacted, which makes sense, as having a C or below is related to end of quarter GPA.

The following regression was used in order to account for effects for each quarter:

$$Y_{it} = \delta_t + \beta FSIM_i + \gamma X_{it} + \varepsilon_{it} \tag{10}$$

where Y_{it} estimates academic achievement of interest, such as end of quarter GPA based on 4.00 scale, an indicator for failed classes (lower than C in any course), or an indicator for dropouts for individual i at time t. β measures the impact of shooting on academic achievement of impacted students enrolled in freshman seminar at t periods prior or after the attack. δ_t, X_{it} , $FSIM_i$ and ε_{it} are same as previous specification in equation (9).

The difference-in-difference graphs in Figure 5 also demonstrate similar results to those found in section 6.1. The estimated average effect of shooting on impacted students GPA decreased by 0.04 point in the end of quarter when shooting occurred, compared to average GPA of non-impacted students in Figure 5(a). After period 0, there's a clear overall increasing pattern in GPA for impacted students relative to non-impacted students. The estimated effect on average percentage of having a C or below increased by 4% for impacted students relative to non-impacted students in period 0 in Figure 5(b). Similar to results above, there's a decreasing trend in percentage of failed classes for impacted students compared to non-impacted students. This means that impacted students passed more classes on average after shooting,

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[14]The OLS estimation is conducted through use of *felm* function in the *lfe* package in R, version 2.8-2.

relative to non-impacted students.The trend of increasing academic success is also present in Figure 5(c). At period 0, the estimated effect of shooting on average percentage of dropout rate increased by 0.2 % for impacted students compared to non-impacted students. Except for abnormally high peak in dropout rate in period 2, there's an overall decreasing trend following the shooting in dropout rates for impacted students on average.

All three difference-in-difference plots in Figure 5 demonstrate increasing academic success for impacted students compared to non-impacted students. However, in the quarter when shooting occurred, the shooting negatively impacted their academic achievement. Similar to arguments made in section 6.1, the grade inflation could have taken place amongst almost all professors to help students to recover from the incident. However, compared to non-impacted students, impacted students could have been harder to concentrate on studies. Then, those impacted students who remained and didn't drop out of school could have slowly recover from incident it is possible that the grade inflation could've sustained for longer periods of time. Also, specific to this subgroup, people often make their first close college friends at classes like freshman seminar, where they have commonality of being freshman and classmates are all new to college. So, people who become friends in freshman seminar have potential to prolong their friendships throughout their time in college. Being more closely connected with those who were killed or injured might be the driving factor of why impacted students in freshman seminar have higher academic achievements after the shooting compared to non-impacted students.

6.3 Robustness Checks

First, I conducted an hypothesis testing to determine whether there's equal chance of an individual being placed in treatment group and a control group. Here, the treatment group in Table 7 contains impacted students who were enrolled in same class with at least one killed or injured students from the incident prior to Spring 2014 quarter in a class size $\leqslant 20$. The treatment group in Table 8 contains impacted students who were enrolled in same class with at least one killed or injured individuals from the shooting who were enrolled in same freshman seminar class prior to Spring 2014 quarter. For both subgroups, the p-values were calculated to see if the difference between means in control and treatment groups were all insignificant at 95% confidence level. The null hypothesis is that the difference between the average student characteristics of impacted and non-impacted students are the same. For example, in the first row for female, non-impacted students in control group were just as likely to be female as impacted

students in treatment group on average. Same inferences can be made for other student characteristic variables (freshman admit, international student, high school GPA, etc), as well as response variables (end of quarter GPA, C or lower in given quarter, and dropout). Thus, it can be said that in terms of student characteristics difference between the control and treatment group, the magnitude of values do not imply a statistically significant difference.

Also, to check if the results for subgroups are robust regardless of adding or removing covariates, I plotted three different difference-in-difference plots from having no controls, only with gender control, and fully specified model in Figure 6 for end of quarter GPA and Figure 7 for having a C or below in any course indicator. These two figures demonstrate that regardless of adding or removing covariates, the overall trends are very similar. This means that regardless of covariates, such as female, admission controls (SAT/adjusted ACT, admission type, high school GPA, transfer GPA, etc), the effect after the attack remains significant. This is also substantiated by the coefficients in Table 9. For the columns 7, 8, and 9, β remained the same regardless or adding or subtracting covariates. The significance level also remained the same. When observing the effect of shooting relative to end of quarter GPA and any course with C or below, the significance level changed slightly. However, it seems like β didn't deviate very much and are all quite similar with adding or subtracting covariates. Thus, it seems reasonable to conclude that the results are robust against addition or removal of covariates. The robustness check was also done for freshman seminar subgroup and the overall patterns were same as well, regardless of addition or subtraction of covariates.

Additionally, for the first subgroup, the definition of impacted students were modified, such as expanding class size restriction to $\leqslant 40$ to see the results still remain robust. Comparing Figure 8 to Figure 4, similar trend holds for both definitions of impacted students. It seems that prior to the attack, individuals in the expanded definition of impacted has slightly higher GPAs than average students after the attack. However, after shooting, it seems that the effect are just as significant as that with class size $\leqslant 20$. Because the trend prior to the attack for both definitions of class size holds similar, we can say that the robustness of the results still holds even if the definition of the impacted students are broadened out.

7 Conclusion

This paper analyzes the impact of college campus shootings on academic achievements of students on mainly two ways: estimating the overall causal effect of shooting and allowing some heterogeneity of the effect of shooting by analyzing the impact of shooting on two impacted subgroups on UC Santa Barbara campus.

The initial hypothesis for overall effect was that students at UC Santa Barbara are likely to demonstrate lower level of academic achievement relative to control campuses and that pattern will continue in the following quarters, as students at UC Santa Barbara will take some time to recover from such traumatic event. However, results from fixed effect model seem to tell us that UC Santa Barbara students had higher end of quarter GPA relative to non-UC Santa Barbara students in Spring 2014 when shooting occurred and also UC Santa Barbara students had lower percentage of receiving a course grade of C or below. After shooting, the following quarters demonstrate decrease in end of quarter GPA and increase in likelihood of receiving a fail grade for a course for UC Santa Barbara students relative to non-UC Santa Barbara students. Also, from synthetic control, we observe similar pattern between UC Santa Barbara and synthetic UC Santa Barbara. Thus, it is likely that there was a grade inflation at UC Santa Barbara to mediate the impact of such a traumatic experience for students.

For analyzing subgroups within UC Santa Barbara, the initial hypothesis was that shooting would negatively impact individuals in both subgroups in Spring 2014 and continue to impact them negatively in the subsequent quarters for some period. Using difference-in-difference method, we showed that the individuals in the first subgroup with class size $\leqslant 20$ were slightly negatively impacted in Spring 2014 quarter. However, there's overall pattern of improvements in academic achievement after period 0. Also, the other subgroup with freshman seminar also resulted in similar outcomes, but the β coefficient was not statistically significant for dropout rates. Perhaps during Spring 2014 quarter, because these students in subgroups are impacted more severely than other students, grade inflation didn't help them as much as other UC Santa Barbara students but afterwards as students start to recover, their academic achievement could have improved in the following quarters.

Thus, examination of aggregate effect of 2014 Isla Vista Killings suggest that campus shooting incident caused grade inflation to occur in UC Santa Barbara in Spring 2014 quarter. However, students at UC

Santa Barbara demonstrated decrease in academic achievement in the subsequent quarters as it takes time for students to recover from such a devastating event occurred on campus. The examination of two subgroups within UC Santa Barbara, seem to suggest that there was no special treatment given to students who were particularly impacted from the shooting compared to other UC Santa Barbara students and instead demonstrated slight decrease in academic achievement in Spring 2014. Because there was an overall grade inflation in UC Santa Barbara as seen by aggregate effect of shooting, this could have just made academic achievement of students in certain subgroups to be lower.

There are some limitations to this research. When examining subgroups in particular, it is possible for the estimates to have downward bias of the overall effect because this incident could have had a great impact in other areas and for individuals not included in the two subgroups. Moreover, this study only examines the impact on students on a short-term and does not provide any long-term effects of school shooting on surviving students. Because these students that we are observing were likely to graduate within few years, we were not able to observe them for period longer than 8 periods before and after Spring 2014. Additionally, there are important questions that could be answered in further research of this particular topic. There was a UC-wide survey conducted few weeks after the shooting called University of California Undergraduate Experience Survey (UCUES). The survey asked students about their campus experiences. This survey could show impacts, such as psychological effects, that could have affected their academic achievement. However, initial analysis of this survey did not bring statistically significant results. Thus, further analysis of this survey could make this research results even stronger.

References

Carla Campbell and Donald F Schwarz. Prevalence and impact of exposure to interpersonal violence among suburban and urban middle school students. Pediatrics, 98(3):396–402, 1996.

Doris R Pastore, Martin Fisher, and Stanford B Friedman. Violence and mental health problems among urban high school students. Journal of Adolescent Health, 18(5):320–324, 1996.

Louis-Philippe Beland and Dongwoo Kim. The effect of high school shootings on schools and student performance. Educational Evaluation and Policy Analysis, 38(1):113–126, 2016.

Weili Ding, Steven F Lehrer, J Niels Rosenquist, and Janet Audrain-McGovern. The impact of poor health on academic achievement: New evidence using genetic markers. Journal of Health Economics, 28(3):578–597, 2009.

David M Fergusson and Lianne J Woodward. Mental health, educational, and social role outcomes of adolescents with depression. Archives of General Psychiatry, 59(3):225–231, 2002.

Sandro Galea and Heidi Resnick. Posttraumatic stress disorder in the general population after mass terrorist incidents: considerations about the nature of exposure. CNS spectrums, 10(2):107–115, 2005.

Seth Gershenson and Erdal Tekin. The effect of community traumatic events on student achievement: Evidence from the beltway sniper attacks. Education Finance and Policy, 13(4):513–544, 2018.

Edward B Blanchard, Dianna Rowell, Eric Kuhn, Rebecca Rogers, and David Wittrock. Posttraumatic stress and depressive symptoms in a college population one year after the september 11 attacks: The effect of proximity. Behaviour Research and Therapy, 43(1):143–150, 2005.

Panu Poutvaara and Olli Tapani Ropponen. School shootings and student performance. Manuscript, 2010.

Cornell, D. (2006). School violence: Fears versus facts. Mahwah, NJ: Lawrence Erlbaum.

Gallup, G., Jr. (1999, May 20). Many teens report copycat-related problems at school in wake of Littleton shooting: Nearly half say their school has violent or violence-prone groups. Retrieved April 2, 2005, from http://www.gallup.com/poll/content/login.aspx?ci=3838.

Anderson, R. N. (2001). Deaths: Leading causes for 1999. National Vital Statistics Reports, 49, 1–88.

Michael J. Furlong, Gale M. Morrison, Dewey G. Cornell & Russell Skiba (2004) Methodological and Measurement Issues in School Violence Research, Journal of School Violence, 3:2-3, 5-12, DOI: 10.1300/J202v03n02_02.

Bryan Vossekuil, Robert A Fein, Marisa Reddy, Randy Borum, and William Modzeleski. The final report and findings of the safe school initiative. Washington, DC: US Secret Service and

Department of Education, 2002.

Folmer-Annevelink, Elvira, et al. "Class Size Effects on The Number and Types of Student-Teacher Interactions in Primary Classrooms." The Journal of Classroom Interaction, vol. 45, no. 2, 2010, pp. 30–38. JSTOR, www.jstor.org/stable/23870349.

Alberto Abadie and Javier Gardeazabal. The economic costs of conflict: A case study of the basque country. American Economic Review, 93(1):113–132, 2003.

Alberto Abadie, Alexis Diamond, and Jens Hainmueller. Synthetic control methods for comparative case studies: Estimating the effect of california's tobacco control program. Journal of the American Statistical Association, 105(490):493–505, 2010.

Lin, Frankie. "School Shootings and Academic Achievement: A Look at the 2014 Isla Vista Killings." UC Berkeley, 2019.

Table 1: Selected Descriptive Statistics and Hypothesis Testing for UC Enrollment Database

	Control Group Mean	**Treatment Group** Mean	**Hypothesis Testing** P-Value
SAT/Adjusted SAT(2400 scale)	1,827	1,844	0.48
High School GPA(5.00 scale)	3.87	3.86	0.50
Freshman Admit	0.82	0.84	0.48
Transfer GPA(4.00 scale)	3.43	3.51	0.44
Female	0.55	0.53	0.51
STEM Courses	0.55	0.35	0.61
White	0.24	0.40	0.40
International	0.04	0.03	0.52
Units	3.72	3.74	0.49
End of Quarter GPA	3.19	3.21	0.49
Course Grade of C or Below	0.16	0.15	0.51
Dropout	0.02	0.01	0.50
Observations	5,491,020	1,690,345	-

Note: The means of each selected independent and dependent variables for control and treatment group is indicated in column 1 and 2. The control group refers to students in UC Santa Barbara and treatment group refers to students in other three UC campuses (Berkeley, Davis, and Riverside). The p-values are calculated in column 3 to see if the difference between means in control and treatment group are significant. The null hypothesis is that the difference between the average student characteristics of students in control and treatment group are same.

Table 2: Fixed Effect Model: Estimated Effect of Shooting

	Dependent variable:		
	End of Quarter GPA	Dropout	Course Grade of C or Below
	(1)	(2)	(3)
UC Santa Barbara:SP14	0.020***	0.005***	−0.006***
	(0.006)	(0.001)	(0.002)
STEM Courses	−0.328***	−0.002***	0.160***
	(0.002)	(0.0005)	(0.001)
Units	0.146***	0.001***	−0.019***
	(0.001)	(0.0001)	(0.0003)
Time Fixed Effects	Yes	Yes	Yes
Observations	1,314,809	1,314,809	1,314,809
R^2	0.583	0.395	0.517
Adjusted R^2	0.498	0.271	0.419
Residual Std. Error (df = 1091450)	0.465	0.102	0.195

*p<0.1; **p<0.05; ***p<0.01

Note: This table shows estimates of the average effect of 2014 Isla Vista Killings on UC Santa Barbara

students compared to non-UC Santa Barbara students under fixed effect model from Equation (1). Time fixed effects included to control for unobserved characteristics that are common to all individual i at a given point in time t. The covariates that varies by each quarter, such as STEM Courses and Units, are included.

Figure 1: Fixed Effect Model: Estimated Effect of Shooting

(a) End of quarter GPA   (b) Course grade of C or below   (c) Dropout
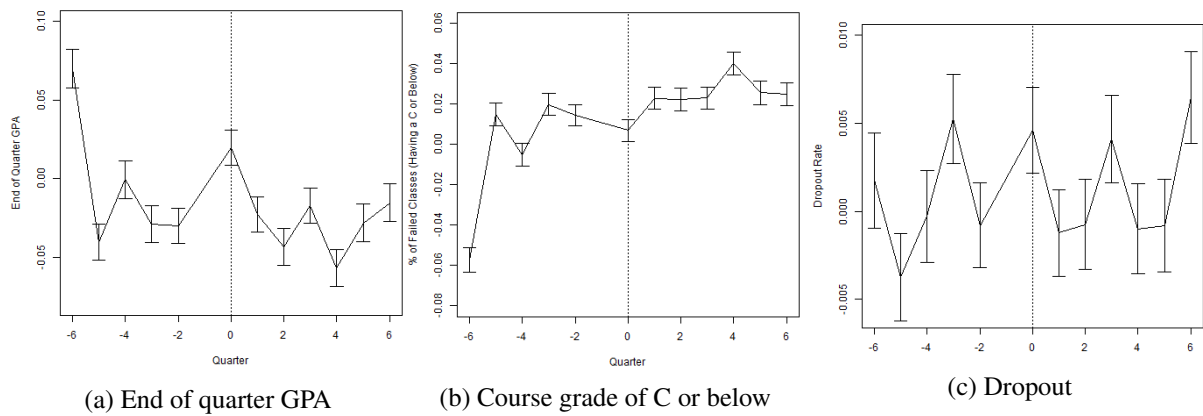
Note: The fixed effect graphs are plotted by using β, an estimate of interest that indicates variable of interest (end of quarter GPA, percentage of having course grade of C or below, and dropout rate) for each quarter. The data is missing data or Winter 2014 quarter for UC Santa Barbara, represented by period -1. Also, data for summer quarters are removed from the data set. Time fixed effects included to control for unobserved characteristics that are common to all individual i at a given point in time t. The error bars indicate 95% confidence interval.

Table 3: Synthetic Control Design: Synthetic Control Weights

|	Outcome		
	End of Quarter GPA	Dropout	Course Grade of C or Below
UC Berkeley	0.42963	0.40164	0.48958
UC Davis	0.57035	0.00289	0.40077
UC Riverside	0.00002	0.59547	0.10965

Note: This table shows synthetic control weights applied to each control campuses (UC Berkeley, UC Davis, and UC Riverside) to create a synthetic control. Each column indicates outcome variable used for measuring academic achievement of students in control and treatment campuses using synthetic control design.

Table 4: Synthetic Control Method: Mean Estimates of Covariates and Dependent Variables

	UCSB	Dependent Variable			Control Group Mean
		End of Quarter GPA	Course Grade of C or Below	Dropout	
SAT/Adjusted SAT(2400 scale)	1,838	1,900	1,858	1,781	2,020
High School GPA(5.00 scale)	3.853	3.991	3.890	3.757	4.12
Freshman Admit	0.84	0.78	0.84	0.83	0.82
Transfer GPA(4.00 scale)	3.47	3.53	3.47	3.34	3.73
Female	0.528	0.544	0.530	0.522	0.53
STEM Courses	0.344	0.584	0.543	0.516	0.54
White	0.418	0.280	0.232	0.194	0.26
International	0.022	0.048	0.036	0.032	0.08
Units	3.728	3.694	3.679	3.712	3.54
End of Quarter GPA	3.120	3.128	3.135	3.08	3.068
Course Grade of C or Below	0.153	0.154	0.151	0.168	0.171
Dropout	0.012	0.009	0.011	0.013	0.011

Note: This table shows mean estimates of covariates and dependent variables under synthetic control method. The treatment group is UC Santa Barbara and control group is composed of other three campuses (Berkeley, Davis, and Riverside). The outcome variables used in this design are End of Quarter GPA, dropout rate, and percentage of having a course grade of C or below. The covariates used include: SAT/adjusted ACT score (2400 scale), High School GPA (5.00 scale), Freshman Admit, Transfer GPA, Female, STEM Courses, White, International, and Units. Column 1 indicates mean estimates for the treatment group and column 2, 3, and 4 contains synthetic estimates weighted based on synthetic weights from Table 3 above. Column 5 indicates mean estimates for control group without synthetic weights where all three control campuses are weighted equally.

Figure 2: Synthetic Control Method: Estimated Effect of Shooting

(a) End of quarter GPA (b) Course grade of C or below (c) Dropout
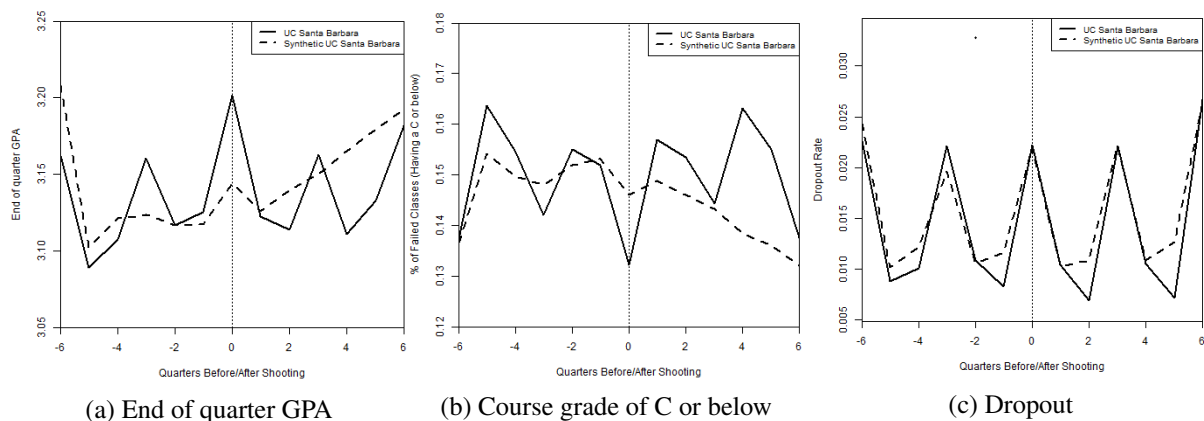
Note: The actual and synthetic control estimates for the effect of the shooting is plotted. The treatment group in this case is UC Santa Barbara and our control group is composed of UC Berkeley, UC Davis, and UC Riverside, weighted using synthetic control method to best resemble unobserved true counterfactual of UC Santa Barbara. The outcome variables used for these plots represent academic achievement of students for each group, which includes end of quarter GPA, percentage of having a curse grade lower than a C, and dropout rate. The covariates used in this model are SAT/adjusted ACT Scores (2400 scale),

High School GPA (5.00 scale), Freshman Admit, Transfer GPA (4.00 scale), Female, STEM Courses, White, International, and Units.

Figure 3: Synthetic Control Method: Estimated Effect of Shooting with Differences

(a) End of quarter GPA   (b) Course grade of C or below   (c) Dropout
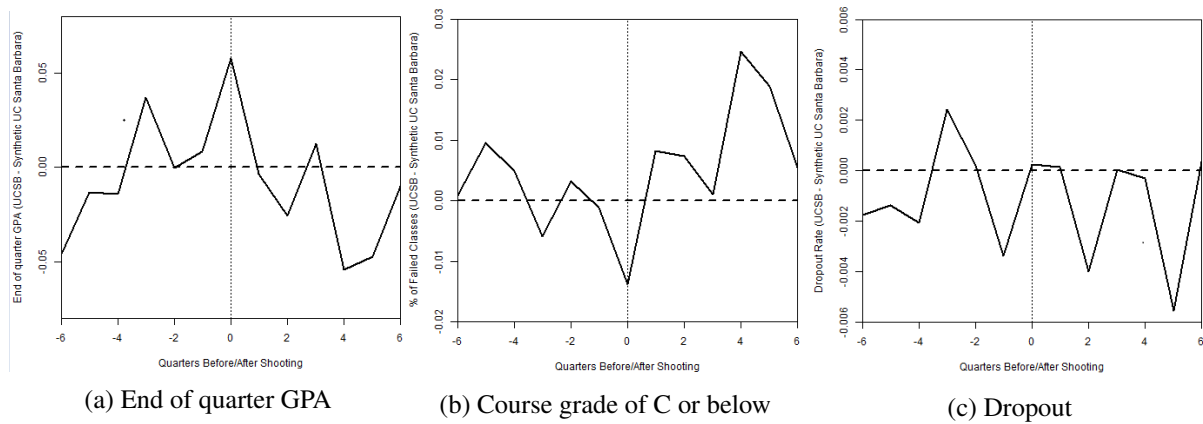
Note: The difference, or the gap between actual and synthetic control estimates for the effect of the shooting is plotted. The treatment group in this case is UC Santa Barbara and our control group is composed of UC Berkeley, UC Davis, and UC Riverside, weighted using synthetic control method to best resemble unobserved true counterfactual of UC Santa Barbara. The outcome variables used for these plots represent academic achievement of students for each group, which includes end of quarter GPA, percentage of having a curse grade lower than a C, and dropout rate. The covariates used in this model are SAT/adjusted ACT Scores (2400 scale), High School GPA (5.00 scale), Freshman Admit, Transfer GPA (4.00 scale), Female, STEM Courses, White, International, and Units.

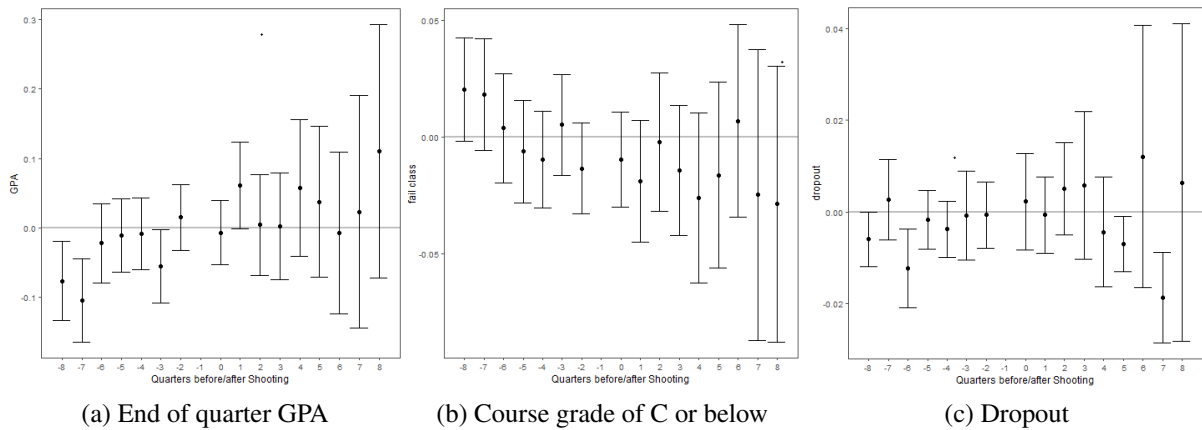Table 5: Difference-in-Difference: Estimated Average Effect of Shooting, Class Size $\leqslant 20$

	Dependent variable:		
	End of Quarter GPA	Course Grade Lower than C	Dropout
	(1)	(2)	(3)
Impacted	−0.003	0.001	−0.007***
	(0.014)	(0.005)	(0.001)
SAT/Adjusted ACT	0.0003***	−0.0001***	−0.00000***
	(0.00001)	(0.00000)	(0.00000)
Freshman Admit	−0.361***	0.119***	0.006***
	(0.023)	(0.007)	(0.002)
High School GPA	0.089***	−0.031***	−0.003***
	(0.005)	(0.002)	(0.0004)
Transfer GPA	0.018***	−0.005***	−0.0003
	(0.002)	(0.001)	(0.0002)
Female	0.063***	−0.017***	−0.004***
	(0.004)	(0.001)	(0.0004)
Impacted:Post	0.064**	−0.017*	0.006**
	(0.027)	(0.009)	(0.003)
Time Fixed Effects	Yes	Yes	Yes
Observations	1,722,196	1,758,847	1,991,823
R^2	0.263	0.174	0.073
Adjusted R^2	0.237	0.145	0.040
Residual Std. Error	0.407	0.178	0.061

Note: *p<0.1; **p<0.05; ***p<0.01

Note: This table shows difference-in-difference estimates of the average effect of 2014 Isla Vista Killings on impacted students compared to non-impacted students from Equation (7). The sample includes individuals enrolled at UC Santa Barbara from 2011 to 2018 who received a final grade at the end of quarter, excluding summer quarters and Winter 2014 quarter. The OLS regressions control for the admission variables (High School GPA, Transfer GPA, SAT / adjusted ACT, admission type (Freshman Admit), and gender (Female).

Figure 4: Difference-in-Difference: Estimated Average Effect of Shooting, Class Size $\leqslant 20$

| (a) End of quarter GPA | (b) Course grade of C or below | (c) Dropout |

Note: The difference-in-difference graphs are plotted by using β, an estimate of interest that indicates the effect of 2014 Isla Vista Killings on academic achievement of impacted students compared to non-impacted students. For this subgroup, impacted students represent individuals enrolled in a class with at least one killed or injured students from the attack prior to Spring 2014 quarter with a class size $\leqslant 20$. It is important to note that the data is missing data for Winter 2014 quarter and it is represented as period -1. Also, data for summer quarters were removed from the data set. Use of OLS regressions control for gender, admissions variables (admission type, high school GPA, transfer GPA, etc.), and fixed time effects. The error bars indicate 95% confidence interval.
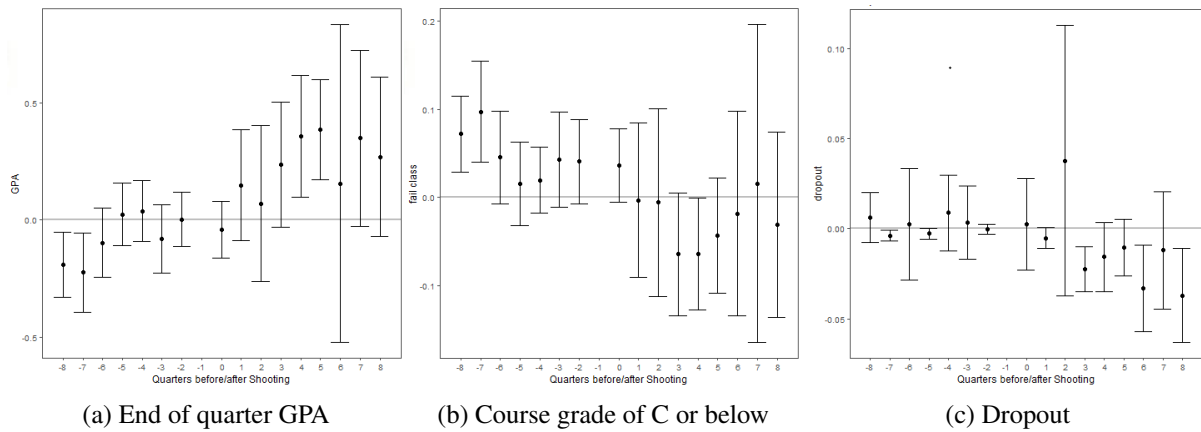
Table 6: Difference-in-Difference: Estimated Average Effect of Shooting, Freshman Seminar

	Dependent variable:		
	End of Quarter GPA	Course Grade lower than C	Dropout
	(1)	(2)	(3)
Impacted	0.048	−0.018	−0.001
	(0.043)	(0.014)	(0.003)
SAT/Adjusted ACT	0.0002***	−0.0001***	−0.00001***
	(0.00001)	(0.00000)	(0.00000)
Freshman Admit	−0.551***	0.206***	0.018***
	(0.023)	(0.008)	(0.002)
High School GPA	0.081***	−0.030***	−0.003***
	(0.005)	(0.002)	(0.0004)
Transfer GPA	0.014***	−0.004***	−0.0005**
	(0.003)	(0.001)	(0.0002)
Female	0.142***	−0.043***	−0.004***
	(0.004)	(0.001)	(0.0004)
Impacted:post	0.303***	−0.077***	−0.010
	(0.110)	(0.029)	(0.010)
Time Fixed Effects	Yes	Yes	Yes
Observations	1,722,196	1,758,847	1,991,823
R^2	0.030	0.016	0.024
Adjusted R^2	0.029	0.016	0.024
Residual Std. Error	0.451	0.191	0.062

*p<0.1; **p<0.05; ***p<0.01

Note: This table shows difference-in-difference estimates of the average effect of 2014 Isla Vista Killings on impacted students compared to non-impacted students from Equation (9). The sample includes individuals enrolled at UC Santa Barbara from 2011 to 2018 who received a final grade, excluding summer quarters and Winter 2014. The OLS regressions control for admission variables (High School GPA, Transfer GPA, SAT / adjusted ACT, admission type (Freshman Admit), and gender (Female).

Figure 5: Difference-in-Difference: Estimated Average Effect of Shooting, Freshman Seminar

(a) End of quarter GPA　　　　(b) Course grade of C or below　　　　(c) Dropout

Note: The difference-in-difference graphs are plotted by using $\hat{\beta}$, an estimate of interest that indicates the average effect of 2014 Isla Vista Killings on academic achievement of impacted students compared to non-impacted students. For this subgroup, impacted students represent individuals enrolled in a freshman seminar class with at least one killed or injured students from the attack prior to Spring 2014 quarter. There was no restriction for the class size for this subgroup. It is important to note that the data is missing data for Winter 2014 and it is represented as period -1 in this plot. Also, data for summer quarters were removed from the data set. Use of OLS regressions control for gender, admissions variables (admission type, high school GPA, transfer GPA, etc.), and fixed time effects. The error bars indicate 95% confidence interval.

Table 7: Descriptive Statistics for Impacted and Non-Impacted Students, Class Size $\leqslant 20$

|	**Control Group**	**Treatment Group**	**Hypothesis Testing**
	Mean	Mean	P-Value
Female	0.53	0.53	0.00
Freshman Admit	0.89	0.77	0.23
International	0.02	0.02	0.01
High School GPA	3.36	2.89	0.22
Transfer GPA	0.41	0.85	-0.24
SAT/Adjusted ACT	1663.13	1488.11	0.19
End of Quarter GPA	2.80	2.74	0.08
Course Grade of C or Below	0.15	0.17	-0.04
Dropout	0.00	0.03	-0.16
Observations	42,550	1,069	-

Note: The descriptive statistics for each independent and dependent variables for control and treatment group is indicated in column 1 and 2. The p-values are calculated in column 3 to see if the difference between means in control and treatment group are significant. The null hypothesis is that the difference between the average student characteristics of impacted and non-impacted students are same.

Table 8: Descriptive Statistics for Impacted and Non-Impacted Students, Freshman Seminar

|	Control Group	Treatment Group	Hypothesis Testing
	Mean	Mean	P-Value
Female	0.71	0.53	0.28
Freshman Admit	1.00	0.77	0.55
International	0.02	0.02	0.01
High School GPA	3.91	2.90	0.59
Transfer GPA	0.00	0.84	-0.57
SAT/Adjusted ACT	1844.55	1491.50	0.47
End of Quarter GPA	2.87	2.74	0.15
Course Grade of C or Below	0.09	0.17	-0.17
Dropout	0.00	0.03	-0.17
Observations	43,507	112	-

Note: The descriptive statistics for each independent and dependent variables for control and treatment group is indicated in column 1 and 2. The p-values are calculated in column 3 to see if the difference between means in control and treatment group are significant. The null hypothesis is that the difference between the average student characteristics of impacted and non-impacted students are same.

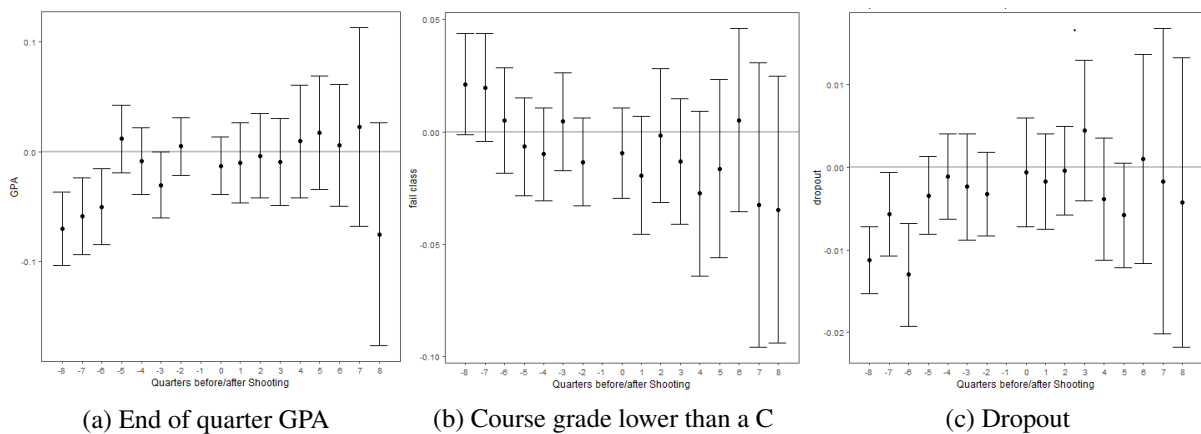Figure 6: Difference-in-Difference: Estimated Average Effect of Shooting on GPA with and without Covariates, Class Size $\leqslant 20$
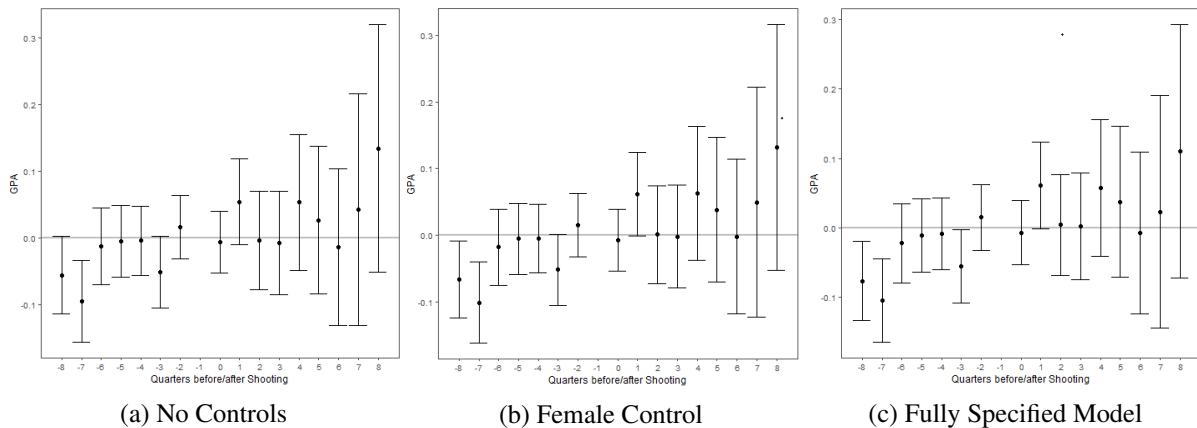
(a) No Controls   (b) Female Control   (c) Fully Specified Model

Note: The difference-in-difference graphs are plotted by using β, an estimate of interest that indicates the average effect of 2014 Vista Killings on end of quarter GPA of impacted students compared to non-impacted students. For this subgroup, impacted students represent individuals who were enrolled in a class with at least one killed or injured students from the attack prior to Spring 2014 quarter with a class size $\leqslant 20$. It is important to note that the data is missing data for Winter 2014 and it is represented as period -1 in this plot. Also, data for summer quarters were removed from the data set. Figure 3(a) is a difference-in-difference graph that plots β when excluding controls, such as admission (high school GPA, transfer GPA, admission type, etc) and gender(Female) control variables. Figure 3(b) is a difference-in-difference graph that plots β when excluding admission control variables (high school GPA, transfer GPA, admission type, etc), but only including gender(Female) control variable. Figure 3(c) is a difference-in-difference graph that plots β for fully specified model that includes all variables.

Figure 7: Difference-in-Difference: Estimated Average Effect of Shooting on Course Grade of C or Below with and without Covariates, Class Size $\leqslant 20$

(a) No Controls   (b) Gender Control   (c) Fully Specified Model
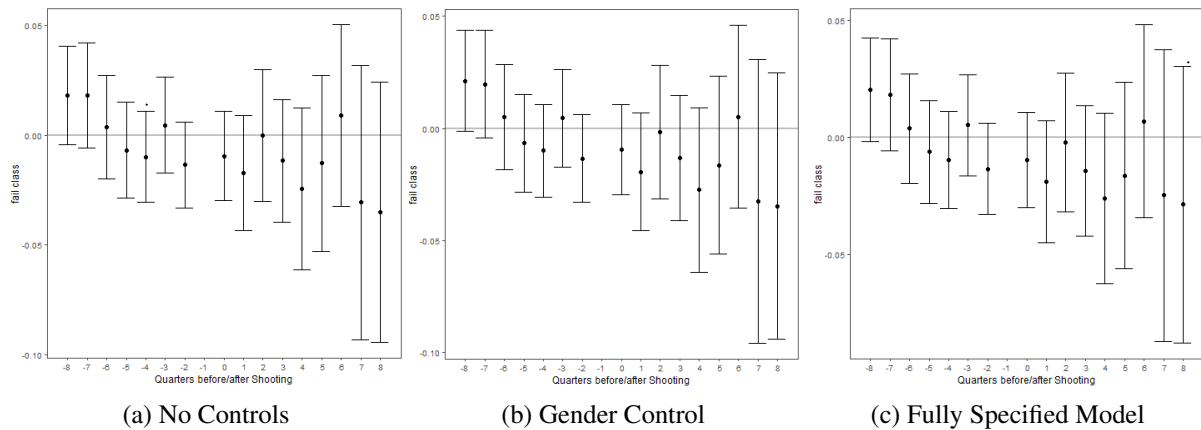
Note: The difference-in-difference graphs are plotted by using β, an estimate of interest that indicates the average effect of 2014 Vista Killings on percentage of having a C or below in any course of impacted students compared to non-impacted students. For this subgroup, impacted students represent individuals who were enrolled in a class with at least one killed or injured students from the attack prior to Spring 2014 quarter with a class size $\leqslant 20$. It is important to note that the data is missing data for Winter 2014 and it is represented as period -1 in this plot. Also, data for summer quarters were removed from the data set. Figure 3(a) is a difference-in-difference graph that plots β when excluding controls, such as admission (high school GPA, transfer GPA, admission type, etc) and gender(Female) control variables. Figure 3(b) is a difference-in-difference graph that plots β when excluding admission control variables (high school GPA, transfer GPA, admission type, etc), but only including gender(Female) control variable. Figure 3(c) is a difference-in-difference graph that plots β for fully specified model that includes all variables.

Figure 8: Difference-in-Difference: Estimated Average Effect of Shooting, Class Size $\leqslant 40$

(a) End of quarter GPA   (b) Course grade lower than a C   (c) Dropout

Note: The difference-in-difference graphs are plotted by using β, an estimate of interest that indicates the average effect of 2014 Isla Vista Killings on academic achievement of impacted students compared to non-impacted students. This plot uses modified definition of impacted students in order to test whether the results for subgroup with class size $\leqslant 20$ is robust. The impacted students in this plot are defined as individuals who were enrolled in a class size $\leqslant 40$ with at least one killed or injured from the attack prior to Spring 2014 quarter. It is important to note that the data is missing data for Winter 2014 and it is represented as period -1 in this plot. Also, data for summer quarters were removed from the data set. The overall trend observed is similar to that with class size $\leqslant 20$.

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Table 9: Difference-in-Difference: Estimated Average Effect of Shooting on Course Grade of C or Below with and without Covariates, Class Size $\leqslant$ 40

	Dependent variable:								
	End of Quarter GPA			Course Grade lower than C			Dropout		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Impacted	0.016	0.013	0.012	−0.007	−0.006	−0.008	−0.007***	−0.006***	−0.006***
	(0.016)	(0.016)	(0.015)	(0.005)	(0.005)	(0.005)	(0.001)	(0.001)	(0.001)
SAT/Adjusted ACT			0.0002***			−0.0001***			−0.00001***
			(0.00001)			(0.00000)			(0.00000)
Freshman Admit			−0.552***			0.206***			0.019***
			(0.023)			(0.008)			(0.002)
High School GPA			0.081***			−0.031***			−0.003***
			(0.005)			(0.002)			(0.0004)
Transfer GPA			0.014***			−0.004***			−0.0005**
			(0.003)			(0.001)			(0.0002)
Female		0.134***	0.142***		−0.041***	−0.043***		−0.004***	−0.004***
		(0.004)	(0.004)		(0.001)	(0.001)		(0.0004)	(0.0004)
Impacted: Post	0.055*	0.066**	0.068**	−0.016*	−0.020**	−0.019*	0.005*	0.005*	0.005*
	(0.029)	(0.029)	(0.028)	(0.010)	(0.010)	(0.010)	(0.003)	(0.003)	(0.003)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,722,196	1,722,196	1,722,196	1,758,847	1,758,847	1,758,847	1,991,823	1,991,823	1,991,823
R^2	0.010	0.016	0.030	0.005	0.008	0.016	0.023	0.024	0.024
Adjusted R^2	0.010	0.015	0.029	0.005	0.008	0.016	0.023	0.023	0.024
Residual Std. Error	0.456	0.454	0.451	0.192	0.192	0.191	0.062	0.062	0.062

*p<0.1; **p<0.05; ***p<0.01

Note: The table shows difference-in-difference estimates of the average effect of the shooting on academic achievement of impacted students compared to non-impacted students with or without covariates. In this table, impacted students is defined as students enrolled in same class as at least one student killed or injured during 2014 Isla Vista Killings prior to Spring 2014 in a class size $\leqslant$ 20. The sample includes individuals enrolled in UC Santa Barbara from 2011 to 2018 who received a final grade at the end of the quarter. This data excludes summer quarters and winter 2014, which was one period before the shooting occurred. column 1 through 3 refer to end of quarter GPA, column 4 through 6 refer to percentage of having a C or below, and column 7 through 9 refer to percentage of dropouts.
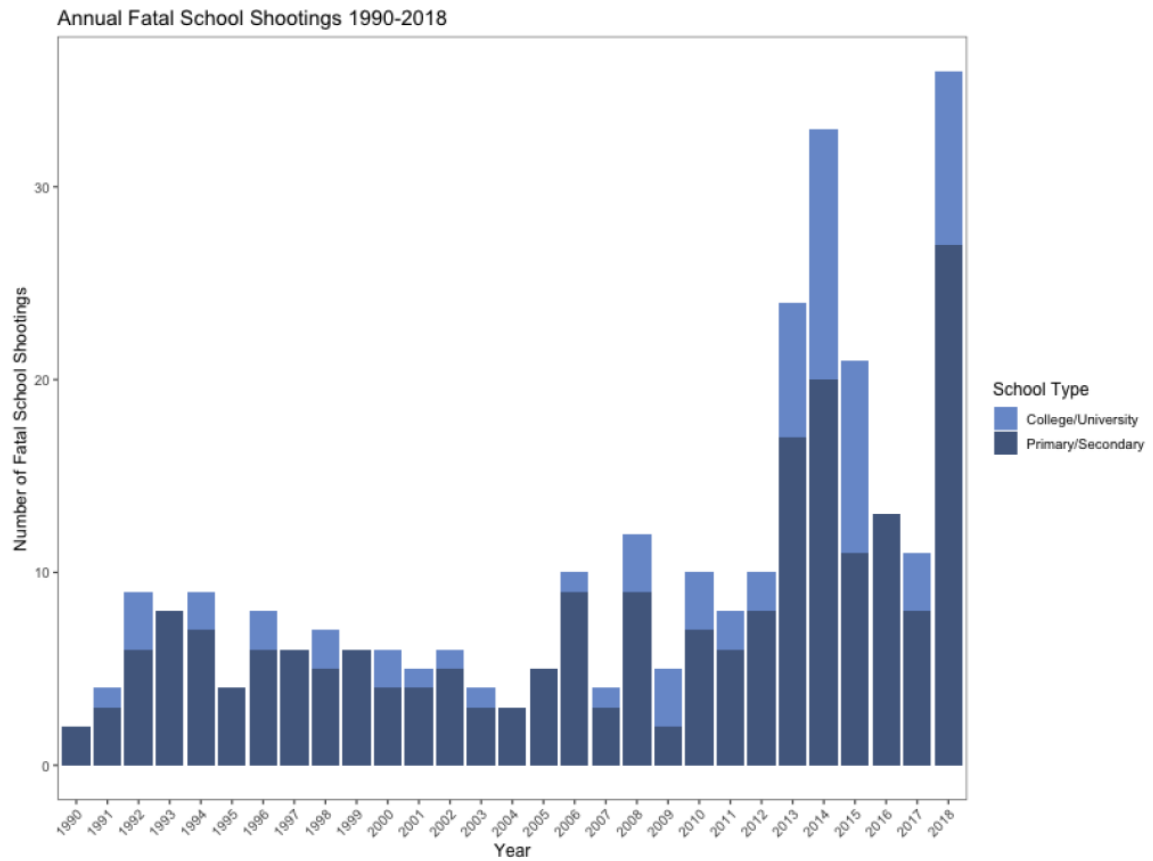
Figure 9: Occurrence of Fatal Shootings, 1990 - 2018
Source: Lin (2019)

Note: A shooting in this figure is defined as any type of shooting targeted towards students or school faculty that occurred near or on a school campus. A shooter as an instructor shooting another instructor is not included in this data, as that is viewed as a workplace shooting, rather than a school shooting. Data source: Wikipedia.