CHARACTERIZING THE EFFECTS OF MILITARY BASE CLOSURES ON THE AMERICAN EDUCATION SYSTEM

by

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DEDICATION

This thesis is dedicated to the memory of Phillip J. Riley. For imparting on me your wisdom and love, I am extremely grateful.

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ABBREVIATIONS

2SLS: Two Stage Least Squares

BRAC: Defense Base Closure and Realignment Commission

CSR: Class Size Reduction

DID: Difference-in-Differences

DoD: Department of Defense

FE: Fixed Effects

FTE: Full-time Equivalent

GAO: Government Accountability Office

NCES: National Center for Education Statistics

OLS: Ordinary Least Squares

RE: Random Effects

ABSTRACT

The effect of military base closures on the pupil-teacher ratios of neighboring elementary schools has not been addressed by past research. Based on NCES and other publicly available data ranging from 1986 to 2012, military base closures (since 1988) have not had a substantial impact on pupil-teacher ratios nor the two populations that make up this measure: the number of students and full-time equivalent teachers. The estimation models included variations in demographics and locales as well as time trends and unknown fixed effects specific to each school and year contained in the dataset. The analysis modeled the base closure process in three separate ways to encompass potential differences in the length and magnitude of such processes. While many of the regressions returned statistically significant coefficient estimates, there was no economic significance to any of the findings.

CHAPTER ONE

INTRODUCTION

In 1988 Congress passed the Defense Authorization Amendments and Base Closure and Realignment Act, the purpose of which was to “provide procedures to facilitate the closure and realignment of obsolete or unnecessary military installations” (Edwards & Ribicoff, 1988). This marked the first formalized, large scale closing of military bases, culminating in the shutdown of seventeen bases no later than September 30, 1995 (Edwards & Ribicoff, 1988). The process was further amended with the passing of the Defense Base Closure and Realignment Act of 1990, establishing the Defense Base Closure and Realignment Commission (BRAC) and effectively laying out the framework for future rounds of base closures (Mason, 2013). Another four BRAC rounds followed the 1990 act, yielding a total of five rounds that have jointly closed and realigned hundreds of bases.[1][2]

The most recent BRAC round, which commenced in 2005, had three commissioners selected by the President with an additional six selected after deliberations with majority and minority leaders of the House of Representatives and the

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[1] The term, “base,” used throughout this thesis, encompasses the main installations of all military branches, though they may be officially referred to as forts, barracks, Air Logistics Centers, Naval Stations, Naval Air Stations, and Naval Training Centers, among others (Nguyen-Hoang, Yeung, & Bogin, 2014; Sorenson, 2007).

[2] The closure of military bases through the first four BRAC rounds seem to coincide, at least in part, with a decreasing trend in the total number of U.S. military personnel. Figure 1 displays this phenomenon.

Senate (Executive Summary, 2005). The commissioners visited many communities and conducted numerous hearings to assess the feasibility of a wide range of potential base closures. All of this was done, as required by law, in an apolitical and objective manner. The selection process primarily focused on operational costs and measures of military readiness, although the economic impact of base closures on affected communities was also taken into consideration (Executive Summary, 2005).

There have been a few studies that have examined the impact of military base closures on existing communities (Cowan, 2012; Dardia, McCarthy, Malkin, & Vernez, 1996; GAO, 2012). A study carried out by the Congressional Research Service summarized the economic impact of base closures and realignments[3] on communities that have been affected in the BRAC rounds leading up to 2005 (Cowan, 2012). Dardia, McCarthy, Malkin, and Vernez (1996) analyzed the impact of three California base closures on their local communities. This research focused more on traditional economic indicators: population, employment, and the housing market.

A 2012 report from the Government Accountability Office (GAO) provided updated cost and expected savings figures based on the realization of the actions recommended in the 2005 BRAC round. While the GAO report provides an example of the costs and benefits of a BRAC round, it also underlines the literature's focus on more common economic measures, in this case, monetarized amounts for costs and expected

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[3] In the context of BRAC, *realignment* can be defined as any action that causes a net decrease in military and/or civilian personnel at a given base due to function relocation (Terms and Definitions, 2005). Realignments are designed to merely reduce the number of personnel at an individual site while keeping the military's overall force at initial levels.

savings. The other two studies used housing prices, unemployment rates, and population counts, among other measures (Cowan, 2012; Dardia et al., 1996). Previous research, with the exception of one recent study, has not examined other economic outcomes of military base closures like their potential effects on education systems.

Nguyen-Hoang, Yeung, and Bogin (2014) characterized the effect of military base closures on two education-related measures from the 1988, 1991, 1993, and 1995 rounds. The two measures included in the research were high school senior graduation rates and per-pupil expenditures. This thesis continued in that spirit and examined the impact of military base closures on a new outcome: the pupil-teacher ratios in affected communities. This thesis also included the more recent 2005 round of closures which was not covered by previous research. Characterizing the impact that base closures may have on American education systems may help influence the decisions of policymakers in future BRAC rounds. Including education-related measures in the commission's selection process criteria would ensure that future commissions take a more holistic and comprehensive approach with regard to making final military base selections.

By addressing the effect of base closures on the pupil-teacher ratio, this thesis focused on one of the main indicators to parents of a school's engagement efforts with respect to their children (Rodriguez & Elbaum, 2013). There is also a large amount of research concerning the pupil-teacher ratio and its relationship with student achievement.

However, the findings[4] are contradictory to one another and researchers have yet to reach a consensus regarding the sign and magnitude of the aforementioned relationship. In spite of this gridlock, the perception of parents, underscored by Rodriguez and Elbaum (2013), may yet be a deciding factor when it comes to policy construction. That is, even if it is shown that there is no significant relationship between the pupil-teacher ratio and student achievement, policymakers may still try to alter pupil-teacher ratios under the expectation that their efforts will garner them public approval and votes. Until the pupil-teacher ratio is soundly proven to be unimportant, research surrounding it still carries merit.

This thesis is the first work to analyze the impact of base closures on pupil-teacher ratios that were reported by each school (i.e. at the school level). The research carried out a decomposition of the pupil-teacher ratio and performed separate analyses that quantify whether the pupil population or the teacher population is affected to a greater extent by BRAC processes. This decomposition approach also addressed the possibility that simultaneous shifts in both the pupil and teacher populations offset one another in the pupil-teacher ratio estimates.

The results of the analysis show statistically significant increases in the pupil-teacher ratios of nearby schools in each of the two years leading up to a base closure, the six years potentially taken to close, and in the two years following a closure. Further decomposed, the number of students attending affected schools increased on average over

[4] Some examples of research findings in favor of a significant relationship between the pupil-teacher ratio and student achievement include Eide & Showalter (1998) and Alspaugh (1994). Examples of findings against include Ehrenberg and Brewer (1994) and Hanushek (1986).

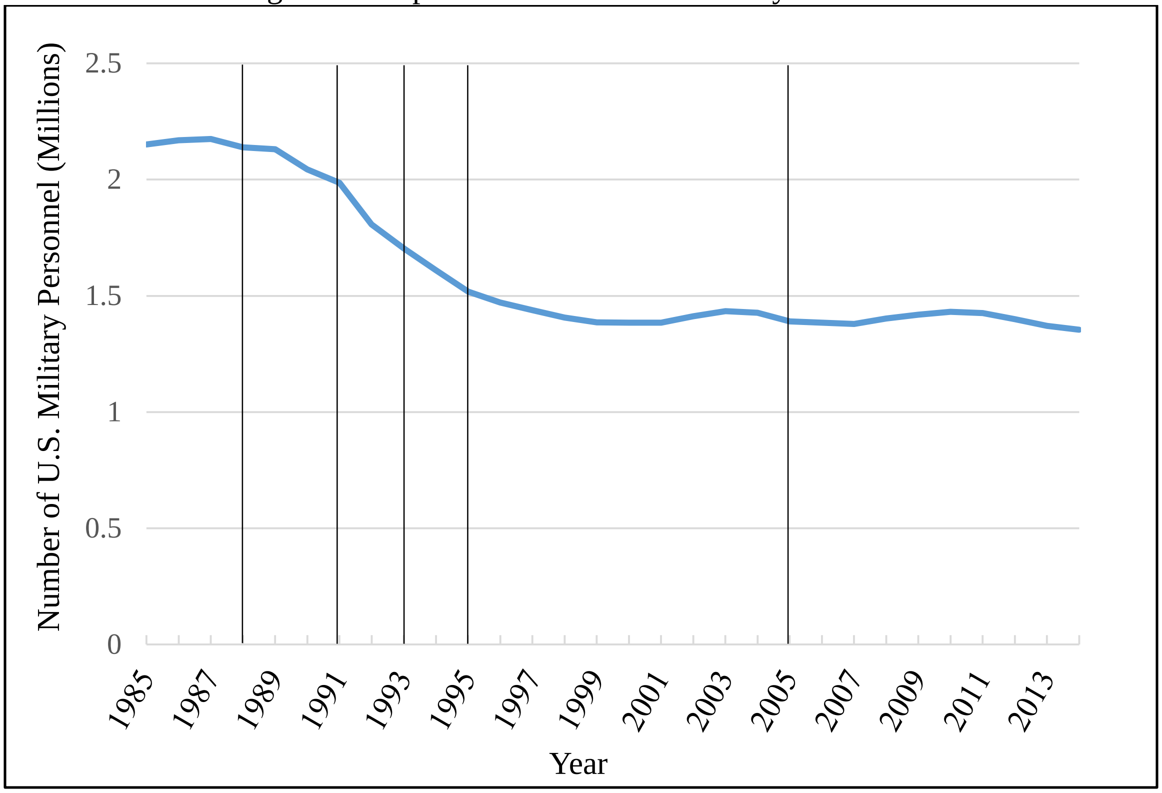
the same time period while the number of teachers decreased (although at an insignificant level). The coefficient estimates regarding this relationship may be statistically significant, but their magnitudes are small.

This thesis alternatively measured the effects of these base closures by averaging pupil-teacher ratios across all years prior to a base closure and comparing this to the average of all years after a closure (as well as the official year of the closure). This particular closure analysis yielded statistically significant coefficient estimates that were opposite in sign to the previous setup which only looked at closure effects in separate years, but also in years prior to the closures. The schools' pupil-teacher ratios decreased on average during and after a nearby base closure. With this same model, the number of students also decreased whereas the number of teachers increased, on average. The coefficient estimates, however, were economically insignificant.

A third and final analysis modeled the effects of the closures as a linear trend. These estimates ranged from weakly statistically significant to insignificant and were also economically small.

The relationships shown in this thesis are small enough in magnitude and have low inferential power such that policymakers may choose to continue omitting the pupil-teacher ratio from the base closure selection criteria without severe repercussions. The lack of any strong effect on the education system parallels that of previously studied economic indicators. This thesis therefore strengthens the literature that concludes that military base closures are not as harsh as initially expected by the public.

Figure 1: Graphical Trend of U.S. Military Personnel



The five vertical bars represent the start of each BRAC round. Military personnel data were obtained from the Defense Manpower Data Center but were initially made available by David Coleman at historyinpieces.com (2014).

CHAPTER TWO

BACKGROUND AND LITERATURE

In an effort to better outline the relationship that was characterized, this chapter first provides an in-depth look at the U.S. military base structure and the BRAC process. It subsequently examines the current literature regarding the economic impact of base closures before detailing the U.S. education system and related measures such as the pupil-teacher ratio. The chapter concludes by reviewing the literature that surrounds the pupil-teacher ratio and its importance to policymakers as well as families.

The U.S. Military Base Structure and the History of BRAC

Since 1985, the United States has consistently ranked in the top four nations with the most military personnel, only surpassed by China, Russia, and India (The World Bank, 2015). Similarly, the Stockholm International Peace Research Institute lists the U.S. as the biggest military spender—in current U.S. dollars—among all nations from 1988 to 2014 (Stockholm International, 2015). Such a large defense organization[5] must be able to adapt to ever-changing political climates, budgets, and both domestic and external threats to national security. This volatility has inevitably closed down numerous bases across the U.S. since World War II and Cold War escalations (Sorenson, 2007).

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[5] For a geographical representation of all current (as of April, 2016) military bases, please see Figure 2 at the conclusion of this chapter. Figure 3 shows the locations of all major military bases that were closed by one of the five realized BRAC rounds.

However, the nation’s pursuit of closures in the past was unclear and potentially influenced by political agendas. To avoid this and to streamline the process, Congress established the aforementioned Defense Base Closure and Realignment Commission in 1988 to select bases for closure without political consideration (Sorenson, 2007).

The most recent BRAC round, beginning in 2005, selected twenty-one bases for closure and thirty-three for realignment. Additionally, the four rounds that preceded it closed and realigned a total of 162 bases (Principi et al., 2005). These closure processes forced the relocation of many military personnel and their families. Because the average number of children for all active duty military members is 0.9, the displacement of military personnel due to base closures also displaces children from school districts in close proximity to such bases (Department of Defense, 2012). This expected displacement of children may be reflected by measures such as class size or even the pupil-teacher ratio in affected communities. A more detailed analysis of the base closure literature follows which better outlines the link between military base closures and pupil-teacher ratios.

Pre-BRAC Closures

Lynch (1970) focused extensively on the base closures that occurred between January, 1961 and April, 1969. During that time period, the Department of Defense (DoD) selected 954 military bases for “closure, cutback, or innovation” (Lynch, 1970).

One portion of the study, using observations from fifteen base closures,[6] found the number of civilian personnel, the number of military personnel at operational bases, and the level of service employment in the local economy to be statistically significant predictors of employment impacts in the local economy due to a base's closure. These findings echo the concerns of communities facing base closures, especially when it is considered that communities with military bases tend to have more service-related jobs than those without military bases (Lynch, 1970).

The report also analyzed the effect of base closures on housing markets, retail sales, and federal funding. The study concluded that a community preparing for a base closure should be ready to experience an abrupt, sharp decrease in its housing market as well as a drop in federal assistance in the form of school funding[7] and economic impact assistance (due to the military presence in the area). However, retail sales in the affected areas were not deeply impacted and no concern should be focused on that particular measure of economic performance (Lynch, 1970). The report did recommend that impact assistance be extended for two years following a base closure because of its relative low cost and the financial stability that it would provide to a recovering locality. The study emphasized that many communities facing base closures do not have the organizational

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[6] The fifteen base closures occurred in the following locations: Mobile, AL; Fort Smith, AR (1959 and 1965); Salina, KS; Lake Charles, LA; Presque Isle, ME; Springfield, MA; Greenville, MS; Sidney, NE; Reno, NV; Roswell, NM; Rome, NY; Greenville, SC; Waco, TX; and Moses Lake, WA.

[7] The school funding mentioned above is a result of Public Law 874, authorized by Congress during the Korean War. It officially provides "assistance for the annual operating costs of schools attended by the children of federally employed civilian and military personnel" (Lynch, 1970).

capacity to oversee a successful and prompt recovery program, but with the DoD Economic Adjustment Program, the recoveries were able to take place with efforts made in the appropriate places. Lynch (1970) sees potential for the recovery experiences chronicled in his analysis to be used in future rounds of base closures and, more broadly, with adjustments following changes in the defense structure of the United States.

BRAC Era Literature

Cowan (2012), in analyzing the impact of base closures, looked at the first four BRAC rounds (i.e. 1988, 1991, 1993, and 1995). The research stated that employment impacts tend to be limited to direct job loss, and that, on average, per capita income is hardly affected by base closures. The report also claimed that the impacts of base closures are oftentimes less than expected because of a military base's isolation. That is, base necessities may be purchased outside of the community and military personnel may also restrict most of their spending to on-base locations. Cowan (2012) also found that school districts that have a large amount of children from military families see enrollment decrease as bases close. This may also coincide with less funding from the government for reasons related to enrollment. Other indirect effects could include lower tax revenues for the area as well as cultural shocks (Cowan, 2012).

Dardia et al. (1996) underscored the fact that California has been hit the hardest by the base closures that began taking place in 1989, effectively losing 21 bases and over 80,000 personnel, and the paper analyzed the short-term effects of three such closures.[8]

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[8] These base closures consisted of George Air Force Base in San Bernardino County, Fort Ord in Monterey County, and Castle Air Force Base in Merced County.

Using measures of population, employment, and the housing market, the study compared the data collected from periods prior to and following the respective closures with similarly collected data from a control group. The control group consisted of California bases that were not closed. Similar to the findings of Cowan (2012), Dardia et al. (1996) reported that the effects were "not catastrophic," nor were they "as severe as forecasted." Following this summation, the report ensured that there are still hardships in the way of job loss and lost revenues but stressed that base closures, and more broadly, defense cuts, are felt more at the individual level than at the community level. The external validity of their research was admitted to be questionable, seeing as the overall sample size was only six bases, but the research came to a conclusion that once again refers to the extent of a base's isolation from the surrounding community: "The degree of integration between bases and local communities can interact to compound or moderate the effects that base closings will have on local communities" (1996).

Nguyen-Hoang, Yeung, and Bogin (2014) examined "the effects of military base closures on educational expenditures and student outcomes" at the school district level between 1990 and 2002. Multiple closure-related causes may be behind alterations in per pupil expenditures, the paper suggested, including a) enrollment reductions leading to increasing spending per pupil, ceteris paribus; b) lower demand for goods and services (like houses) which in turn decreases the tax base and through it, school budgets; c) lower personal income (with education considered to be a normal good); d) loss of federal funding from the Impact Aid Program (which was a product of Public Law 874, discussed above). Potential changes in the graduation rates for high school seniors were included in the analysis as a measure of base closures' effects on student outcomes.

In addition to a standard Difference in Differences (DID) approach, Nguyen-Hoang et al. (2014) also ran Two Stage Least Squares (2SLS) regressions using multiple instrumental variables and used propensity score matching techniques to create treatment and control groups whose comparisons would be relevant. The 2SLS regressions which used propensity score matching returned statistically significant coefficient estimates regarding graduation rates suggesting that, on average, graduation rates decreased by nearly sixteen percentage points in the year of a base closure. Concerning per pupil expenditures, a significant, positive result was found using the same methods. With respect to both dependent variables, neither regression exhibited post closure trends (characterized by the interaction between district and year dummies) that were statistically significant. In other words, the only significant impact of military base closures in this context was seen in the year of the actual closure. This finding coincides with the current economic literature on military base closures which suggests that such events are not as catastrophic as anticipated (Nguyen-Hoang et al., 2014).

Nguyen-Hoang et al. (2014) concluded that the increase in spending per pupil was due to a combination of two mechanisms. One was the expected decrease in student enrollment while the other was actually an increase in federal aid in the year of the base closures to help ease the transition for the community. When looking at student outcomes, the study suggested that the lower graduation rates may be a result of many of the military children being high achievers who would have graduated if not for the closure. Another possible explanation is the psychological impact that the closure may have had on students who lost friends that were uplifted because of the base closure.

With regard to the most recent BRAC round, GAO (2012) found that the costs of implementing final closures and realignments increased by sixty-seven percent over their original estimates. Such costs oftentimes reflect positive impacts on existing communities.[9] Expected savings decreased from the original estimated 20-year net present value of $35.6 billion to $9.9 billion (GAO, 2012). In annual terms, net savings will decrease from about $4.2 billion to $3.8 million. The increase in implementation costs is largely due to unforeseen building expenditures at bases that were selected for realignment (GAO, 2012).

As of right now, there are no other published studies concerning the BRAC rounds and their economic impacts. Nor are there any studies that include the effect of the 2005 BRAC round on the education system, the closest study being the one detailed by Nguyen-Hoang, Yeung, and Bogin (2014) for the previous BRAC rounds.

The U.S. Education System and the Pupil-teacher Ratio

The United States has structured its education system in such a way that its students attend primary (elementary) school, middle school, and secondary (high) school before moving on to higher education options if so desired (U.S. Department of

[9] For example, the Fort Belvoir Community Hospital was made to be more energy efficient through the realignment process; it now consumes “thirty percent less energy than the medical facilities it replaces” (Ward, 2011).

Education, 2015). Corsi-Bunker (2015) states that the federal government only influences education through funding, leaving education in the U.S. largely up to state and local governments. Most states require schooling from five or six years of age until a student is sixteen years old, though a minority require their students to stay in the system until they are eighteen (Corsi-Bunker, 2015).

Relevance to the U.S. Military

The military, like many other facets of life, can be inextricably linked to the U.S. education system. The first, and perhaps the most obvious link, is the compulsory nature of education in every state and the military's requirement that a certain level of education be attained before being considered eligible to enlist or otherwise be commissioned. More specifically, a high school diploma "is desirable, although not mandatory," but a citizen may still enlist if they score above the thirty-first percentile on the Armed Forces Qualification Test (Office of the Federal Register, 2015). This underscores the importance of education to the military as far as its enlistment/commissioning standards are concerned.

The focus of this research, however, centers on the children of parents who serve in the military. Decisions that impact the military may indirectly impact these children and the schools they attend. Because children of military parents are in school until at least sixteen years of age, base closure decisions in particular have the potential to affect where these children go to school. For example, if it is decided that a certain base is to be closed, the military personnel who were formerly stationed on said base now have to relocate to a base that is still operational. This move inevitably causes the children of military parents to have to switch schools between communities. Such movements are expected to affect enrollment figures and other such measures at both schools near closed military bases as well as those located near bases that remain operational.

Not only are there logistical issues present, but parents and policymakers alike place importance on where children go to school due to differences in quality between schools and the positive benefits of receiving a good education (Black, 1999; Greenstone, Harris, Li, Looney, & Patashnik, 2012). In addition, schools near military bases may experience changes in class sizes and pupil-teacher ratios (through changes in enrollment) during the realization of base closure processes. These measures alone are under a lot of public scrutiny for reasons to be detailed in the next subsection.

The Significance of the Pupil-teacher Ratio

Both class size and pupil-teacher ratios have historically been used in evaluating educational settings, though their definitions are different. Class size can be thought of as the number of students assigned to a specific teacher for the school year while the pupil-teacher ratio is the total number of students in the school divided by the total number of full-time equivalent teachers at that school. The point of discernment is that of the pupil-teacher ratio and its inclusion of support staff such as librarians, computer lab technicians, and even school principals. Because of the differences in calculation required by the two measures, the pupil-teacher ratio is often smaller than the reported average class size for a given unit of measurement (Lewit & Baker, 1997). These measures can be aggregated and viewed at the district, state, and national levels. Lewit and Baker (1997) stated that both measures have declined in the long run and the National Center for

Educational Statistics (NCES) affirms that that trend has continued over a time span that now exceeds fifty years (2014).

Pupil-teacher ratios have been shown to be one of the strongest indicators to parents of a school's engagement efforts (Rodriguez & Elbaum, 2013). For this reason alone, the pupil-teacher ratio may be a measure that many policymakers choose to focus on, especially if they hold elected positions. However, this measure may also affect levels of student achievement, a relationship that was probed by numerous studies over the years but has thus far yielded contradictory findings, as detailed below.

Some research, like that of Ehrenberg and Brewer (1994) and Hanushek (1986), finds evidence against a relationship between the pupil-teacher ratio and student achievement as measured by standardized test scores (as cited in Eide & Showalter, 1998). However, Eide and Showalter (1998), after computing quantile regressions, found a statistically significant relationship between per pupil expenditures and average test score gains for the lower end of the distribution. These findings suggest that disadvantaged and minority students may experience greater benefits from the enactment of certain policies. The aforementioned studies do differ in how they were built and whom they address but a trend is apparent with regard to ethnic and socioeconomic status. Further research has indicated that a link between pupil-teacher ratios and student achievement may also be affected by grade level (Alspaugh, 1994).

Evidence in support of a link between pupil-teacher ratios and student achievement stems from two large-scale class size reduction (CSR) programs. Tennessee's Project STAR (Student-Teacher Achievement Ratio) was implemented in

1985 in an effort to examine smaller class sizes as measured by the pupil-teacher ratio and how they may affect student achievement (Mosteller, 1995). The study divided students at eligible schools[10] into three different types of classrooms: (a) small classes ranging from thirteen to seventeen students; (b) regular size classes with 22-25 students; (c) regular size classes with a teacher's aide. The observation period ran from 1985 to 1989 with a separate phase devoted to following students after 1989 as they returned to regular size classes. By reviewing Stanford Achievement Test scores, which can be compared nationwide, Mosteller (1995) found that students participating in Project STAR had performance gains of one-fourth of a standard deviation. This improvement could move a student from the fiftieth to the sixtieth percentile of Stanford Achievement Test scores. Students who were placed in small classes or regular size classes with a teacher's aide continued to score higher on average than their peers after transitioning back to regular size classes in the fourth and fifth grades. Additionally, it was found that minority students benefitted almost twice as much as majority students from smaller classes in the early grades.

Krueger & Whitmore (2001) performed a long-term follow up of Project STAR by focusing on the narrowing of the black-white achievement gap both in terms of standardized test scores and rates at which college entrance exams were taken. The study found that the narrowing of the black-white test score gap could almost entirely be explained by national trends in pupil-teacher ratios for black and white students. The

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[10] Schools from all types of residential areas were eligible as long as they had at least fifty-seven children in every grade which would allow the researchers to make comparisons within schools (Mosteller, 1995).

paper also found that the black-white gap narrowed with regard to the likelihood a student took a college entrance exam (e.g. SAT, ACT). In addition, past enrollment in a small class was shown to drive higher gains in SAT and ACT test scores among black students than it did among white students.

The Student Achievement Guarantee in Education (SAGE) program was implemented in Wisconsin beginning in the 1996-1997 academic year (Molnar et al., 1999). In the SAGE program, schools reduced their class sizes to fifteen students for every one teacher. This was achieved by team-teaching, installing temporary partitions, and using “floating teachers,” the latter case defined as a classroom of thirty students and one teacher which gains an additional teacher during the instruction of language arts, reading, and math to bring the class size down to the required fifteen-to-one. Molnar et al. (1999) found a student’s attendance at a SAGE school to be statistically significant as an indicator of student achievement in the second year of the program (compared to the first, baseline year). The magnitude of the estimator ranged between three and seven points, about 0.1 to 0.2 standard deviations in score increases on the Terra Nova[11] exam. It was also found that African-American students in the SAGE schools recorded higher test score gains than their control counterparts as well as higher gains than the white students in the SAGE schools. This latter point complemented the findings of previous literature as well as those of Project STAR in which minority students were found to be impacted more significantly by CSR programs as opposed to majority students.

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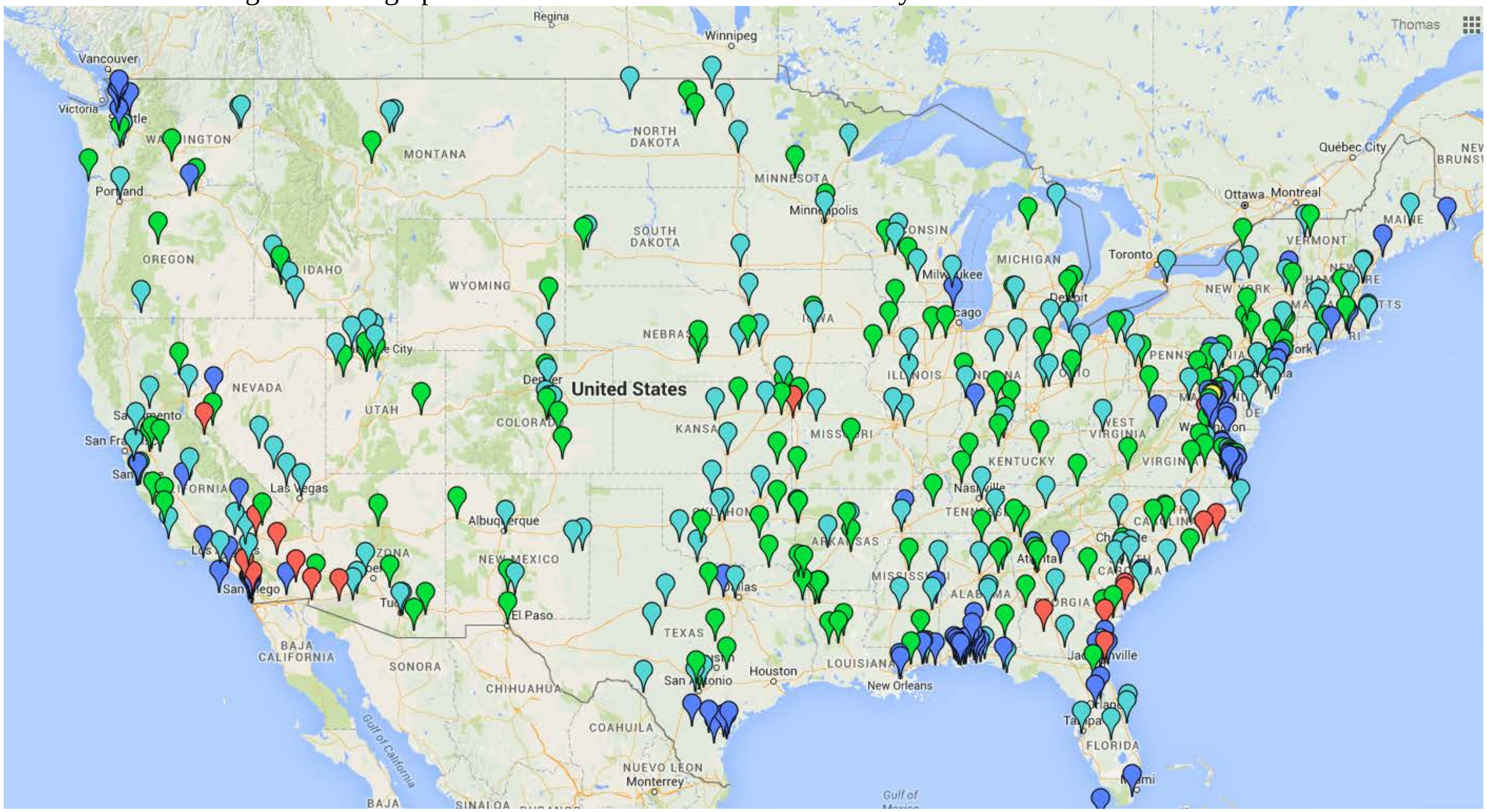
11 The Terra Nova exam is more formally known as the Comprehensive Test of Basic Skills, or CTBS.

A failed CSR program implemented in California highlights the necessity of employing experienced teachers (Jepsen & Rivkin, 2002). In an effort to decrease pupil-teacher ratios across the state, California hired many additional teachers in order to better distribute the number of students in its school system. However, this action led to the hiring of many inexperienced teachers as there simply were not enough qualified teachers to meet California's demand due to the policy. This led to students in California, in many cases, seeing no improvement in academic performance (Jepsen & Rivkin, 2002). Minorities and disadvantaged students were even hindered by California's CSR program (Stiches, Bohrnstedt, Kirst, McRobbie, & Williams, 2001). As such, the results of CSR programs must be analyzed alongside knowledge of the teacher pool.

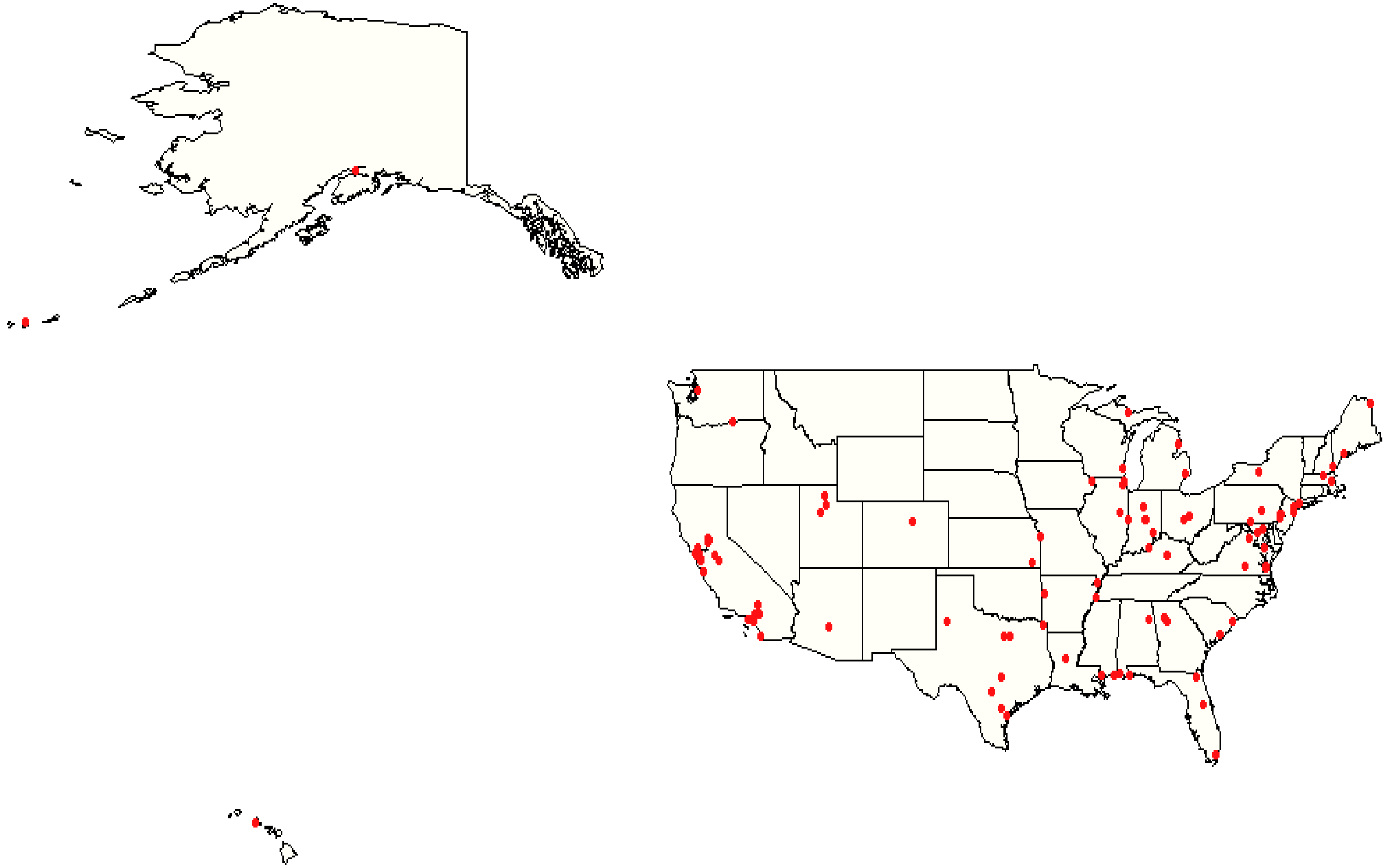
It has thus been shown that the pupil-teacher ratio can be an important measure in the eyes of policymakers and parents as well as a tool for strengthening the academic performance of majority and minority students, though the latter group receives more of a benefit. It is expected that military base closures lead to changes in the pupil-teacher ratios of nearby schools, but this effect has yet to be characterized. Given the importance of the pupil-teacher ratio, the impact of base closures on such a measure may be knowledge of tremendous value to policymakers and citizens alike. This thesis sought to reveal the nature of that impact.

Figure 2: Geographical Distribution of all Current Military Bases in the Continental U.S.



Note: Bases are color coded by branch of service. Green markers indicate Army bases, light blue markers indicate Air Force bases, dark blue markers denote installations belonging to the Navy, and red-orange markers denote Marine Corps bases.

Figure 3: Locations of all Major Installations Closed during a BRAC Round



Note: All major closures plotted on the above map were approved during one of the BRAC rounds beginning in the following years: 1988, 1991, 1993, 1995, and 2005.

CHAPTER THREE

DATA OVERVIEW

In order to estimate the impact of military base closures on the education system, data were collected from numerous sources. The educational data were recorded and made available by the NCES beginning with the 1986/1987 academic year. All of the information was originally collected on behalf of the NCES' Common Core of Data program as well as its Private School Survey. The Common Core of Data is run annually and gathers its information from state agencies. This information encompasses demographics, fiscal data, geographic details, and many more descriptive points. The Private School Survey is conducted biennially and collects similar data from administrative personnel at each responding school (NCES). Both survey results were compiled by the NCES and are available to the public through the agency's Elementary/Secondary Information System which allows users to download the information that they desire for use in statistical analyses. This database is the source from which pupil-teacher ratios, demographic data, student and teacher population data, and locale data were downloaded for the purposes of this research.

The information regarding the military component of this research was collected manually from the numerous BRAC documents that were published over the years. More specifically, lists of major base closures were compiled by consulting the "Final Selection" documents from each BRAC round. The year in which a base officially closed was obtained for each military base from a document that summarized all BRAC closures up to the time that it was published. This did not cover the most recent round of base closures that have been enacted since 2005, so these dates were then ascertained from various news sources and base webpages. All major base closures, the states in which they are located, and the years in which they were closed are listed in Appendix A.

Sets of coordinates for each school were obtained from the same NCES source as before. Coordinates were also obtained for each military base but because there is no readily available database that lists military bases and their geographic positioning, coordinates were collected manually by referencing each base's GeoHack[12] profile. The coordinates for the schools and the military bases were crucial in matching each base to the relevant (elementary) schools within a set radius. This matching process is explained more in the following section.

Because a majority of the children whose parents serve in the military are of the age at which they would attend elementary schools,[13] the dataset was restricted so that the impact of military base closures was only measured with regard to nearby elementary schools (i.e. all data pertaining to middle and high schools were ignored, as the impact on them was expected to be much more subtle). To provide a sense of the dataset in its elementary-school-only form, descriptive statistics are compiled in Table 1. For comparison, descriptive statistics are also provided for the following subsections of the dataset: a) elementary schools

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12 GeoHack is a "modified version of map sources…used by Wikipedia to provide links to various mapping services when a user clicks on a link with geographical coordinates (MediaWiki, 2015).

13 According to the 2013 Demographics Report, about 68.2% of Active Duty and Selected Reserve children are eleven years or younger in age (DoD, 2013). This is assumed to extend back to the start of this analysis, in the 1986/1987 academic year.

that are located within a ten mile radius of a military base that closed during the analysis (Table 2); b) elementary schools that are located within a ten mile radius of a military base that remained operational during the course of the analysis (Table 3); c) all elementary schools that do *not* fall within a ten mile radius of any military base, regardless of its operational status (Table 4).

Table 1. Descriptive Statistics for all Elementary Schools

Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
Pupil-teacher Ratio	17.21	8.45	0.09	1292.67	720091
Total Number of Students	494.01	232.40	2.00	12192.00	720091
Number of FTE (Full-time Equivalent) Teachers	29.57	13.77	1.00	782.60	720091 720091
Percentage Free Lunch Eligible Students	39.80	26.26	0.06	133.46	720091 720091
Percentage Hispanic Students	17.18	23.67	0.05	99.91	720091
Percentage Black Students	16.93	24.26	0.04	134.29	720091
City Location	0.26	0.44	0.00	1.00	720091
Suburb Location	0.34	0.47	0.00	1.00	720091
Rural Location	0.18	0.38	0.00	1.00	720091

Table 2. Descriptive Statistics for the Elementary Schools Located Within a Ten-Mile Radius of Military Bases that Closed

Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
Pupil-teacher Ratio	18.37	8.88	0.23	1124.00	98026
Total Number of Students	547.17	232.46	5.00	3832.00	98026
Number of FTE (Full-time Equivalent) Teachers	31.05	13.55	1.00	212.00	98026 98026
Percentage Free Lunch Eligible Students	46.13	29.25	0.09	113.17	98026 98026
Percentage Hispanic Students	26.20	27.08	0.06	99.90	98026
Percentage Black Students	24.26	28.70	0.07	134.29	98026
City Location	0.46	0.50	0.00	1.00	98026
Suburb Location	0.42	0.49	0.00	1.00	98026
Rural Location	0.02	0.14	0.00	1.00	98026

Table 3. Descriptive Statistics for the Elementary Schools Located Within a Ten-Mile Radius of a Military Base that Remains Operational

Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
Pupil-teacher Ratio	17.15	6.80	0.09	634.00	90110
Total Number of Students	543.61	245.26	4.00	3530.00	90110
Number of FTE (Full-time Equivalent) Teachers	32.40	13.74	1.00	227.40	90110 90110
Percentage Free Lunch Eligible Students	42.16	27.75	0.09	358.04	90110 90110
Percentage Hispanic Students	25.06	29.76	0.08	99.88	90110
Percentage Black Students	23.44	27.20	0.06	108.61	90110
City Location	0.44	0.50	0.00	1.00	90110
Suburb Location	0.40	0.49	0.00	1.00	90110
Rural Location	0.05	0.22	0.00	1.00	90110

Table 4. Descriptive Statistics for all Elementary Schools Not Located Within a Ten-Mile Radius of a Military Base

Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Count**
Pupil-teacher Ratio	17.03	8.36	0.09	1292.67	622065
Total Number of Students	485.63	231.28	2.00	12192.00	622065
Number of FTE (Full-time Equivalent) Teachers	29.33	13.79	1.00	782.60	622065 622065
Percentage Free Lunch Eligible Students	38.80	25.62	0.06	133.46	622065 622065
Percentage Hispanic Students	15.76	22.76	0.05	99.91	622065
Percentage Black Students	15.77	23.28	0.04	112.76	622065
City Location	0.23	0.42	0.00	1.00	622065
Suburb Location	0.33	0.47	0.00	1.00	622065
Rural Location	0.20	0.40	0.00	1.00	622065

CHAPTER FOUR

METHODOLOGY

In order to isolate the effect of military base closures on schools' pupil-teacher ratios, student populations, and teacher populations, the following regression model was used:

$$Y_{it}=\beta_0+\beta_1 Treatment_{it}+\beta_2 X_{it}+\sum_{t=1986}^{2012}\gamma_t Year_t+\sum_{i=1}^{n}\delta_i School_i+\varepsilon_{it} \quad (1)$$

where *i* and *t* serve as indices for the particular school and year, respectively, of each observation. *Y* denotes one of the dependent variables, *X* is a vector of control variables that vary across school and time, and ε is the error term. The control variables encompassed by X are the percentage of students that are Hispanic, the percentage of students that are black, and the percentage of students that are eligible for free lunches. These controls are included in the model because they may be correlated with both the pupil-teacher ratio of a school and whether or not that school's nearby military base was closed during one of the BRAC rounds.

The three dependent variables that replace Y are the pupil-teacher ratio, the total number of students, and the total number of FTE teachers. *Year* and *School* are each binary variables equal to unity when they match up with an observation's year or school value and equal to zero in all other cases. These variables control for year specific fixed effects and school specific fixed effects, the latter of which includes indicators of whether a school is located in an urban, suburban, or rural setting, that may not be explained by the other control variables. *Treatment* may be one of three different vectors used in the analysis. The next section describes each of these treatment vectors and the motivation for using them.

Constructing Different Treatment Vectors

Because the actual length of time it takes for military base closures to be fully realized is unknown, three different treatment vectors were used in the analysis. The first treatment vector is a binary treatment variable that is equal to zero in all years prior to a base closure (for the schools matched to that base) and equal to one in the year of the closure as well as all successive years. This isolated the effect of base closures on nearby schools by removing the effects of years prior to the closure and, through the comparison to unaffected schools, removed any effects shared by the treatment and control groups.

One potential shortcoming of this treatment vector's construction is that, if a base closure was realized over a long period of time, especially in advance of the official closure date, then averaging data in the year of the base closure with all succeeding years could be diminishing the estimated effect of that closure. With many bases notified of their closure up to six years in advance of their deadline, bases may have chosen to gradually downsize in terms of personnel and military operations. To acknowledge this possibility, a second treatment vector was constructed which is equal to unity only in the year of a base's closure and equal to zero in all other years. It will continuously be referred to as the "single year treatment vector." This vector was then led and lagged so that the effects of each base closure (by year) could be studied up to eight years prior to the official closure date as well as two years following the official closure. This approach addressed the possibility that bases were closed down gradually, requiring families to move before the official closure. The treatment vector mentioned at the start of this section would not have picked up such movements.

A third and final treatment vector also assumed that the base closure processes were long and drawn out over time, but it was constructed in a way that estimates a linear treatment effect across time (i.e. it treats the impacts of base closures equally in each year of the time series). Extending six years before and after each base closure, this linear treatment vector is equal to zero in the year of the base closure, negative one and one in the year prior to a base closure and the year immediately after a base closure, respectively, and this pattern continues until values of negative six and six are associated with school level data six years prior to a closure and six years after a closure. See Table 5 for a side-by-side example comparison of the three treatment vectors that were used in this analysis.

Identification Strategy

To characterize the impact that military base closures have had on nearby schools, an ideal experiment would track all schools within ten miles of every stateside military base from 1985 to 2015. For each school, data would be recorded over that time period concerning demographics, student and teacher populations, and most importantly, the pupil-teacher ratio. Military bases would be selected at random for undergoing closure processes with their respective school matches making up the treatment group. The control group would then consist of all remaining schools that were matched to bases not randomly selected for closure. To simplify the characterization of base closures, the closure process would take place overnight and every base selected for closure would close simultaneously. As part of the process, military families that work at a base selected for closure would be removed from the population entirely so as to avoid their transferring to the control group. The precise enactment of the treatment would allow for changes in the pupil-teacher ratio, the total number of students, and the total number of teachers to be easily identified through regression analysis.

In reality, school level data were available for the period of 1986-2012, nearly meeting the ideal dataset length. They consisted of demographic information (e.g. the number of Hispanic and black students), counts of student and teacher populations, and the desired pupil-teacher ratio as well as geographical coordinates to help with the matching process. Matching schools to bases was implemented by matching all schools within ten miles of a military base to that same base, as it is assumed that the vast majority of children of military parents attend schools within ten miles of the base at which their parents are stationed. However, this is where the research starts to diverge from the ideal experiment. Military bases were not selected for closure at random but instead were chosen based on a number of criteria. Additionally, the closures were not carried out overnight, nor were they conducted simultaneously. Military families that had to relocate from a base that was closed were not removed from the population. All of these departures from the ideal experiment required that certain specifications be made to the model to avoid biased estimates of the treatment effect.

The control variables detailed earlier were included in the model to reduce any omitted variable bias that may have been introduced by the nonrandom selection of bases for closure. The treatment vectors used in this analysis were constructed individually for each base closure depending on the official year of closure. They were also built in three different ways (detailed above). Together, these strategies address the variance in the closure dates and the unknown length of the closure processes.

Elementary schools that reside within ten miles of a base that closed due to the BRAC process made up the treatment group. The control group, however, consisted of all elementary schools that were *not* located within ten miles of any military base, regardless of its closure status. The schools matched to bases that remained operational were omitted from both the treatment and control groups. This action was taken in order to avoid a spillover effect that may have occurred when families moved from a closing base to an operational base. That is to say, schools near bases that remained operational may have seen an increase in enrollment due to family relocation. These demographic changes render such schools inadequate as members of a true control group because they were indirectly affected by the closure processes. Furthermore, if it is found that pupil-teacher ratios decreased in schools near closed military bases and, at the same time, it is found that pupil-teacher ratios increased in schools near operational bases, then the impact of these BRAC closures would have been overestimated if the schools near operational bases were included in the control group.

In fact, regressions were run with the operational bases as a part of the control group[14]. Most of the coefficient estimates of interest were smaller in magnitude compared to the regression estimates which omitted operational bases from the control group. After this check, operational bases continued to be left out of the control group to avoid underestimating the impact of military base closures on any of the three dependent variables.

A variable that may be correlated with both pupil-teacher ratios and base closures is that of a school's locale type (e.g. urban, suburban, rural). For example, if schools near

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[14] Results from this comparison are available upon request.

military bases tend to be located in more urban environments, then it is possible that those schools' pupil-teacher ratios are larger than those of schools in the control group which may be located in more rural areas. This potential difference across the treatment and control groups was controlled for so that it was not included in the estimated closure effect. Because locale types remained constant over the course of this dataset, they were controlled for using school specific fixed effects. Such an approach effectively eliminated any other school specific variables that remain constant over time that may also have affected the sought after estimation. Unknown variables specific to a given year could also have biased the regression results. These variables, by virtue of being constant over time, were controlled for by including year fixed effects in the model. Both classes of fixed effects are ranges of binary variables, the same ones denoted in Equation 1 at the beginning of the chapter as *Year* and *School*. All the included controls and specifications heretofore mentioned allowed the research design to be as close to the ideal experiment design as possible.

Additional Methods

The typical standard errors used in an OLS setting rely on the assumption that the variance of the unobserved error term is constant. When this assumption does not hold, it is said that heteroskedasticity is present and this renders invalid the standard errors from before (Wooldridge, 2012). As such, heteroskedasticity-robust standard errors were calculated and reported with the regression results.

Likewise, when calculating a standard error, it is assumed that each observation is independent of the others in the dataset and that each one reports the same amount of unique information. But if it turns out that multiple observations are correlated, then the typical standard error that is used is inflated. The standard errors in this analysis were clustered on schools to avoid such a mistake.

A random effects (RE) model was considered as an alternative to the FE model because it retains more variation in the data. However, its assumption that the unobserved heterogeneity is uncorrelated with the independent variables is considered to be too strong in this context. Nevertheless, overidentification tests were run to compare the estimates from the FE and RE models for each specification.[15] The reported Sargan-Hansen test statistics for each specification are listed in Table 6. In every case, the test statistic was large enough to warrant using a fixed effects model instead of the random effects variant.

[15] An overidentification test was used instead of a Hausman test because it is robust to the clustering of the standard errors on each school (as cited in Cameron & Trivedi, 2005).

Table 5. Side-by-side Comparison of all Treatment Vectors (Example)

Treatment:	"Typical" Treatment Vector	"Single Year" Treatment Vector	"Linear" Treatment Vector	Variables		
Description:	Equal to zero in all years prior to a base closure; equal to one during and after closure.	Equal to one in the year of a base closure and equal to zero in all other years.	Equal to the year of a base closure minus the year of a given observation (with values no greater than six in absolute value).	Year	Closure Year	Base
	0	0	-6	1994	2000	Base A
	0	0	-5	1995	2000	Base A
	0	0	-4	1996	2000	Base A
	0	0	-3	1997	2000	Base A
	0	0	-2	1998	2000	Base A
	0	0	-1	1999	2000	Base A
	1	1	0	2000	2000	Base A
	1	0	1	2001	2000	Base A
	1	0	2	2002	2000	Base A
	1	0	3	2003	2000	Base A
	1	0	4	2004	2000	Base A
	1	0	5	2005	2000	Base A
	1	0	6	2006	2000	Base A

This example shows the three different treatment vectors and their corresponding values across the time period 1994-2006 for a single base, Base A, which closed in the year 2000.

Table 6. Overidentification Test Results from each Fully Specified Model

	Dependent Variables		
Treatment Variables	Pupil-teacher ratio	Total # of Students	Total FTE Teachers
Single-year Treatments	533.92	1021.22	846.66
	(0.00)	(0.00)	(0.00)
Typical Treatment	503.00	986.47	771.82
	(0.00)	(0.00)	(0.00)
Linear Treatment	139.32	126.47	96.60
	(0.00)	(0.00)	(0.00)
Demographic Variables	YES	YES	YES
Locale Controls	YES	YES	YES
Year FE	YES	YES	YES
School FE	YES	YES	YES
Observations	720,091	741,790	720,091
R-squared	0.024	0.035	0.044
Number of uniqueid	56,909	57,660	56,909

Notes: P-values for each Sargan-Hansen test statistic are listed in parentheses directly underneath the applicable statistic. The Single-year Treatment vector is equal to unity only in the year of a base closure and equal to zero in all other years. The Typical Treatment vector is equal to unity in the year of a base closure and all following years. It is equal to zero in all years prior to a closure. The Linear Treatment vector is equal to zero in the year of a closure, -1 and 1 in the years just before and after a closure, and this pattern continues out to -6 and 6.

CHAPTER FIVE

ANALYSIS AND RESULTS

Table 7 provides coefficient estimates in column 1 from regressing the pupil-teacher ratio on the series of “single year” binary variables surrounding the date when a military base was closed, controlling for demographic measures, locale differences, year fixed effects, and school fixed effects. By controlling for year fixed effects, a time trend was also implicitly controlled for. This equation is hereby referred to as the “fully specified” FE model regarding the impact of military base closures (in each year, separately) on the pupil-teacher ratios of nearby elementary schools. Column 2 also reports estimates from a fully specified model but details instead the effects of base closures on the student population, once again detailed eight years prior to the official closure and two years after by including a series of single year binary variables. Likewise, Column 3 contains estimates of the effects of base closures on the number of full-time equivalent teachers at a school. For a plotted representation of the point estimates and their standard errors from Table 7, Columns 1, 2, and 3, please reference Figures 4, 5, and 6, respectively.

The results indicate that, over the eight years before a base closure, nearby schools experienced statistically significant yearly increases in their pupil-teacher ratios, though by no more than an average of 1.54 pupils per teacher in a given year. The official year of each closure as well as the two years following it show similar coefficient estimates that are also statistically significant but small in magnitude. Estimated changes in the total number of students showed a similar trend: all estimates were positive, most were statistically significant, and the biggest estimate was an average increase in 14.48 students. The coefficient estimates for the number of full-time equivalent teachers were only statistically significant for four out of the eleven years. They were mostly negative in sign, with a change in sign occurring during the year of the official base closures. Then the estimates were positive but very small in magnitude. The most negative estimate in this column was -0.83.

The results regarding the total number of students and the number of FTE teachers noticeably drive the estimated changes in the pupil-teacher ratio, as an increase in the numerator of the pupil-teacher ratio (total number of students) and a simultaneous decrease in the denominator (number of FTE teachers) leads to a larger overall ratio, as shown by the positive signs in column 1. Even when there are estimated increases in the number of FTE teachers, the magnitude of the increases in the student population seem to outweigh those of the former, yielding positive estimates again for the pupil-teacher ratio.

While the majority of the estimates in Table 7 are statistically significant at the 95% and 99% confidence levels, the magnitudes of each of these estimates are small, even when reviewing the summary statistics for elementary schools located around a closed base. For example, referring to Table 2, the average pupil-teacher ratio for affected schools is 18.37. Based on the largest result from Column 1, an increase of 1.54 pupils per teacher, such a pupil-teacher ratio would be expected to increase from 18.37 to 19.91 on average which is only 17.3% of a standard deviation. Similarly small increases and decreases relative to the averages in Table 2 can be calculated with respect to the student and FTE teacher populations.

Panel 1 in Table 8 consists of three columns which regress each dependent variable separately on the treatment vector that is equal to unity in the year of a base closure and all following years while being equal to zero in years prior to the closure. This treatment vector is hereinafter referred to as the “typical treatment vector” because it is the construction that is most often used in DID analyses. All three equations were once again fully specified and controlled for the same variables and fixed effects as before. Column 1 regressed the pupil-teacher ratio on the typical treatment vector and estimated an average decrease of 0.71 students per FTE teacher. Column 2 shows the regression output of the student population regressed on the same treatment vector. In that case it was estimated that the number of students decreased by an average of 10.98 at affected elementary schools during and after the base closures. Column 3 contains output from the regression of the number of FTE teachers on the typical treatment vector, the coefficient estimate of which was 0.30.

The coefficient estimates from columns 1 and 2 were both statistically significant at the 99% level and the estimate from column 3 was insignificant. The magnitudes of each of these estimates were small relative to the population means and standard deviations reported in Table 2: The estimated decrease in the average pupil-teacher ratio was from 18.37 to 17.66 and is only 8% of a standard deviation. Likewise, an estimated decrease in the average number of students at a school from 547.17 to 536.19 and an increase in the average number of FTE teachers from 31.05 to 31.35 are only 4.7% and 2.2% of a standard deviation in each respective group.

If it is instead assumed that base closure processes are gradual but implemented equally over time, then the regressions that make up Panel 2 of Table 8 should be reviewed. Panel 2 consists of columns 4, 5, and 6 which regress separately the pupil-teacher ratio, the number of students, and the number of FTE teachers on the "linear treatment vector." This linear treatment vector extends six years on either side of a base's official closure date. Such a construction allowed for the possibility that the military base closures conducted throughout the history of the BRAC program were slowly implemented and any measurable effects from these closures may be viewed equally by year.

It was estimated that the pupil-teacher ratio of affected elementary schools decreased by an average of 0.21 over the period of thirteen years encompassed by the linear treatment vector. The number of total students and number of FTE teachers at affected elementary schools were estimated to have decreased by 5.85 and 0.14 over the same time period. The coefficient estimate regarding the pupil-teacher ratio (Column 4) was not statistically significant. The estimates of the effects on the student and teacher populations (Columns 5 and 6) were both statistically significant at the 95% confidence level. The magnitudes of all three estimates were insignificant.

To review basic regression results and how they changed as more controls were added to each model (up to the point where they became fully specified), please refer to Tables 9 through 17 in Appendix B.

Locale Type Investigation

While locale types were controlled for in the initial analysis, it may be of interest to examine how the impacts of military base closures differ across locale types. Tables 18 and 19, located in Appendix C, display the regression results from limiting the population to elementary schools that were located in urban settings. The regression models were identical to those that were run in the initial analysis. Using the main specification, the estimated changes in the pupil-teacher ratios were slightly larger in magnitude compared to those that correspond to the entire population. Estimated changes in the total number of students and the number of FTE teachers, however, were mostly smaller in magnitude. The statistical significance of all of the urban specific estimates were qualitatively similar to the originals. Using the typical and linear treatment vectors, the coefficient estimates for the pupil-teacher ratio and the number of students were slightly larger in magnitude while the estimates for the number of FTE teachers were smaller in magnitude. Panel 1 saw no changes in the statistical significance of its estimates whereas the estimates in Panel 2, after limiting the population to urban schools, had their statistical significance diminish or disappear outright.

This same process was repeated after limiting the population to elementary schools located in suburban areas, the results of which are listed in Table 20, also in Appendix C. Focusing on the main model, the estimated changes in the pupil-teacher ratio by year were greatly diminished in magnitude—after limiting the population to suburban schools—such that most of them lost their statistical significance. Many of the estimates for the total number of students flipped to negative signs after limiting the population, their absolute magnitudes increasing on average but statistical significance diminished for most estimates. Estimates for the number of FTE teachers did not change much, their signs stayed the same as before, and statistical significance was lost for the earlier estimates (i.e. those 6-8 years before a closure). Table 21 lists regression output based on the linear and typical treatment vectors after limiting the population to suburban schools. No changes worth mentioning occurred to the estimates from the linear treatment model (Panel 2). Using the typical treatment vector (Panel 1), small changes in the magnitudes of the pupil-teacher ratio and the number of FTE teachers were observed. A very large change was observed with the total number of students. The coefficient estimate when the entire population was used was -10.98 (Table 8, Column 2) but limiting the population changes it to 11.71 (Table 21, Column 2). For an unknown reason, military base closures have an opposite effect on the student populations in suburban schools as opposed to the average effect on schools in all types of locales.

Finally, Tables 22 and 23 were constructed to display regression output from the same models, but after limiting the population to elementary schools in rural areas. Regarding the main model, focusing on rural schools decreased the coefficient estimates for the pupil-teacher ratio in terms of magnitude and most became statistically insignificant. A few estimates changed sign but were so close to zero that the sign changes were assumed to be negligible. The number of FTE teachers did not see many changes in any respect. It can only be stated that the coefficient estimates decreased slightly in absolute magnitude. The big changes occurred with respect to the student population. All of the signs became negative after limiting the population with most of the absolute magnitudes increasing by considerable amounts as well. It is worth mentioning though that the standard errors also became inflated to the point where the statistical significance of many of the estimates was lost after restricting the population. These results suggest that rural schools see larger decreases in their student population as a result of base closures when compared to the average effect on the entire population. However, the inflation of the standard errors may imply that such large impacts are experienced by very few (rural) schools. Table 23 shows that coefficient estimates from the linear treatment model (Panel 2) are qualitatively similar across population specifications. Results from using the typical treatment vector (Panel 1) show another sign change in the total number of students from negative to positive. The estimate itself changed from -10.98 to 30.32 but statistical significance was lost.

Restricting the Population by State

Using all elementary schools not within ten miles of a military base as the control group injected considerable heterogeneity into the analysis. For this reason, regressions were also run after restricting the population to elementary schools located in California (California having been selected because of its large number of major base closures, 27, that have been implemented during the BRAC era). This effectively limited the control group to schools that would be more similar to those in the treatment group by virtue of residing in the same state and region. As in the preceding section, the same regression models were used which consist of the three dependent variables of interest as well as the three different treatment vectors detailed earlier.

Table 24 in Appendix D lists the coefficient estimates from regressing all three dependent variables on the main model. Compared to the initial analysis, the pupil-teacher ratio estimates changed only slightly in magnitude and all but one of those was a decrease. The statistical significance largely vanishes after restricting the population to California schools. Conversely, the estimates for the number of FTE teachers all became positive and some even became more statistically significant than the initial estimates. Estimates for the total number of students mainly increased in magnitude but their statistical significance remained similar to before. All in all, Table 24 suggests that California schools experienced greater increases in their student populations due to base closure processes than did the average of all schools. California schools also experienced small increases in their FTE teacher populations instead of decreases that were felt by the original treatment group.

Table 25, also in Appendix D, lists coefficient estimates from regressing the dependent variables of interest on the linear and typical treatment vectors. The estimates associated with the linear treatment vector (Panel 2) did not undergo remarkable changes when restricting the population to California schools. By modeling the closure processes in the typical fashion (Panel 1), it was found that California schools had no sizeable change in their pupil-teacher ratios, the estimated change in the total number of students remained very close to that of the overall population, and the number of FTE teachers decreased on average for California schools (at a statistically significant level) whereas the overall population saw an impact in the FTE teacher population that was insignificant and close to zero.

With the exception of the estimated increases in the total number of students using the main model, all coefficient estimates for the California school population were still economically insignificant. Why were the California estimates regarding the student population larger than in the initial analysis? Perhaps decreasing housing prices, caused by military families leaving a community, combined with the allure of living in California led to greater influxes of families compared to communities around the rest of the United States. In any case, this analysis emphasizes how base closures can have greater or lesser effects on certain populations than on others, but that pupil-teacher ratios seem to be largely unaffected by BRAC processes. The scope of an analysis will ultimately determine which population is studied. This particular research focused more on average effects across the nation to better inform future BRAC commissioners of how their selections may impact the U.S. as a whole.

Measuring Demographic Changes due to Base Closures

Military base closures were expected to have a negative impact on pupil-teacher ratios as well as the student populations at affected schools. The positive coefficient estimates in Table 7, Columns 1 and 2 run contrary to these expectations. One potential explanation as to why these results were observed is that with numerous families leaving an area, housing prices could have decreased such that new families surged into the area to take advantage of the low prices. This influx of non-military families replacing the old ones may have been large enough to outweigh the impact of those who left, thereby resulting in a net positive outcome in terms of the student populations and pupil-teacher ratios. To analyze this possibility, and to more thoroughly document the effects of base closures on certain demographics, numerous regressions were run with the following as dependent variables: a) the percentage of students at a school who are eligible for free lunches; b) the percentage of students who identify as Hispanic; c) the percentage of students who identify as black.

Compiled in Table 26, Appendix E are estimates from regressing the aforementioned dependent variables on the main model: the series of single year binary variables. These results indicate consistent, statistically significant increases in the percentage of students eligible for free lunches (Column 1), decreases in the percentage of students identifying as Hispanic (Column 2), and increases in the percentage of students identifying as black (Column 3). These increasing percentages of free lunch eligible students may indicate that poorer families are indeed taking advantage of the depressed housing prices during the base closure processes. Additionally, student populations were estimated to be increasingly made up of black students over the course of base closures whereas the Hispanic component decreased. Why the two races are affected in opposite directions is unclear, though if military populations tend to be more Hispanic than black, and black families are the ones largely taking advantage of depressed housing prices, the above estimates would certainly be explained.

Table 27 in Appendix E indicates no linear trends (Panel 2) in any of the demographic variables. But regressing the demographic variables on the typical treatment vector yielded coefficient estimates which were opposite in sign to those in Table 26. That is, in the years after a base closure, the percentage of free lunch eligible students was estimated to decrease by an average of .65, the percentage of Hispanic students was estimated to increase by an average of 3.49, and the percentage of black students, an average decrease of 1.59. The sign changes between Tables 26 and 27 are puzzling. It may be that all of the demographic variables are affected in opposite manners when comparing the period during a base closure to the period following one.

Policy Implications

In all BRAC rounds to date, only a few potential consequences of base closures faced by schools were factored into the decision making process. In order to better inform policymakers and affected individuals alike, this analysis was performed to characterize the effects of military base closures on schools' pupil-teacher ratios as well as the components that it consists of. Based on the estimates yielded by this research, future BRAC commissioners may be able to overlook the impact of their decisions on elementary schools in the form of changes in student and teacher populations as well as the pupil-teacher ratio itself. That is, military base closures did not have economically significant impacts on the chosen dependent variables, even after modeling the closures in three different ways. Consequently, BRAC commissioners need not worry extensively about the relationships detailed in this research when making final closure selections.

Furthermore, parents of students that remain in closure-affected areas (i.e. parents who are not part of the military nor are moving away) do not have to worry about large changes in pupil-teacher ratios, student populations, or teacher populations in one direction or the other. Although statistically significant estimates were found with both positive and negative signs depending on the chosen treatment vector, the magnitudes of the estimates were small.

Table 7. Regression Output from Main Model (Series of Single Year Treatment Vectors)

Independent Variables	Dependent Variables (1) Pupil-teacher ratio	(2) Total # of Students	(3) Total FTE Teachers
Single Year Treatment in Year T-8	1.54***	14.48**	-0.74**
	(0.20)	(6.22)	(0.34)
Single Year Treatment in Year T-7	0.94***	3.48	-0.77***
	(0.14)	(5.55)	(0.28)
Single Year Treatment in Year T-6	1.05***	6.68	-0.83***
	(0.14)	(4.73)	(0.26)
Single Year Treatment in Year T-5	0.60***	9.12*	-0.23
	(0.14)	(4.68)	(0.24)
Single Year Treatment in Year T-4	0.73***	8.41**	-0.46**
	(0.12)	(4.06)	(0.22)
Single Year Treatment in Year T-3	0.47***	9.68***	0.07
	(0.12)	(3.72)	(0.21)
Single Year Treatment in Year T-2	0.50***	7.08**	-0.10
	(0.10)	(3.46)	(0.19)
Single Year Treatment in Year T-1	1.35***	7.98**	-0.05
	(0.46)	(3.32)	(0.20)
Single Year Treatment in Year T	0.42**	7.65**	0.11
	(0.17)	(3.09)	(0.19)
Single Year Treatment in Year T+1	0.77**	11.99***	0.18
	(0.31)	(2.97)	(0.19)
Single Year Treatment in Year T+2	0.50***	11.43***	0.01
	(0.10)	(2.68)	(0.16)
Demographic Variables (% Hispanic, % Black, % Free Lunch Eligible)	YES	YES	YES
Locale Controls (Urban, Suburban, and Rural)	YES	YES	YES
Year FE	YES	YES	YES
School FE	YES	YES	YES
Observations	773,969	773,969	773,969
R-squared	0.03	0.04	0.04
Number of uniqueid	60,475	60,475	60,475

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The treatment vector is equal to unity in the year of a base closure and zero in all other years. Lagged and led versions are also added to the model as specified above.

Table 8: Regression Results from Regressing all Three Dependent Variables on the Typical and Linear Treatment Vectors

	Panel 1: Typical Treatment Vector			Panel 2: Linear Treatment Vector		
Description:	Equal to unity in the year of a base closure and all successive years, zero in all years prior to closure.			Equal to zero in the year of a base closure, -1 and 1 in the year before and year after the closure, and this trend continues out to -6 and 6.		
	(1) Pupil-teacher ratio	(2) Total Number of Students	(3) Number of FTE Teachers	(4) Pupil-teacher ratio	(5) Total Number of Students	(6) Number of FTE Teachers
Treatment	-0.71***	-10.98***	0.30	-0.21	-5.85**	-0.14**
	(0.12)	(3.22)	(0.19)	(0.23)	(2.54)	(0.06)
% of Students that are Hispanic	-0.00	1.07***	0.10***	0.01	0.89***	0.06***
	(0.00)	(0.06)	(0.00)	(0.02)	(0.33)	(0.02)
% of Students that are Black	-0.01***	-0.22***	0.02***	0.01	-0.04	-0.03*
	(0.00)	(0.07)	(0.00)	(0.02)	(0.34)	(0.02)
% of Students Eligible for a Free Lunch Program	-0.02***	-0.61***	-0.02***	0.02	-0.19	-0.01
	(0.00)	(0.03)	(0.00)	(0.01)	(0.13)	(0.01)
Linear Treatment Squared				-0.01**	-0.11	-0.00
				(0.00)	(0.10)	(0.01)
Demographic Variables	YES	YES	YES	YES	YES	YES
Locale Controls (Urban, Suburban, Rural)	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
School FE	YES	YES	YES	YES	YES	YES
Observations	773,969	773,969	773,969	16,170	16,170	16,170
R-squared	0.03	0.04	0.04	0.05	0.05	0.17
Number of uniqueid	60,475	60,475	60,475	1,994	1,994	1,994

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Figure 4: Pupil-teacher Ratio Point Estimates and Standard Errors from Table 7, Column 1

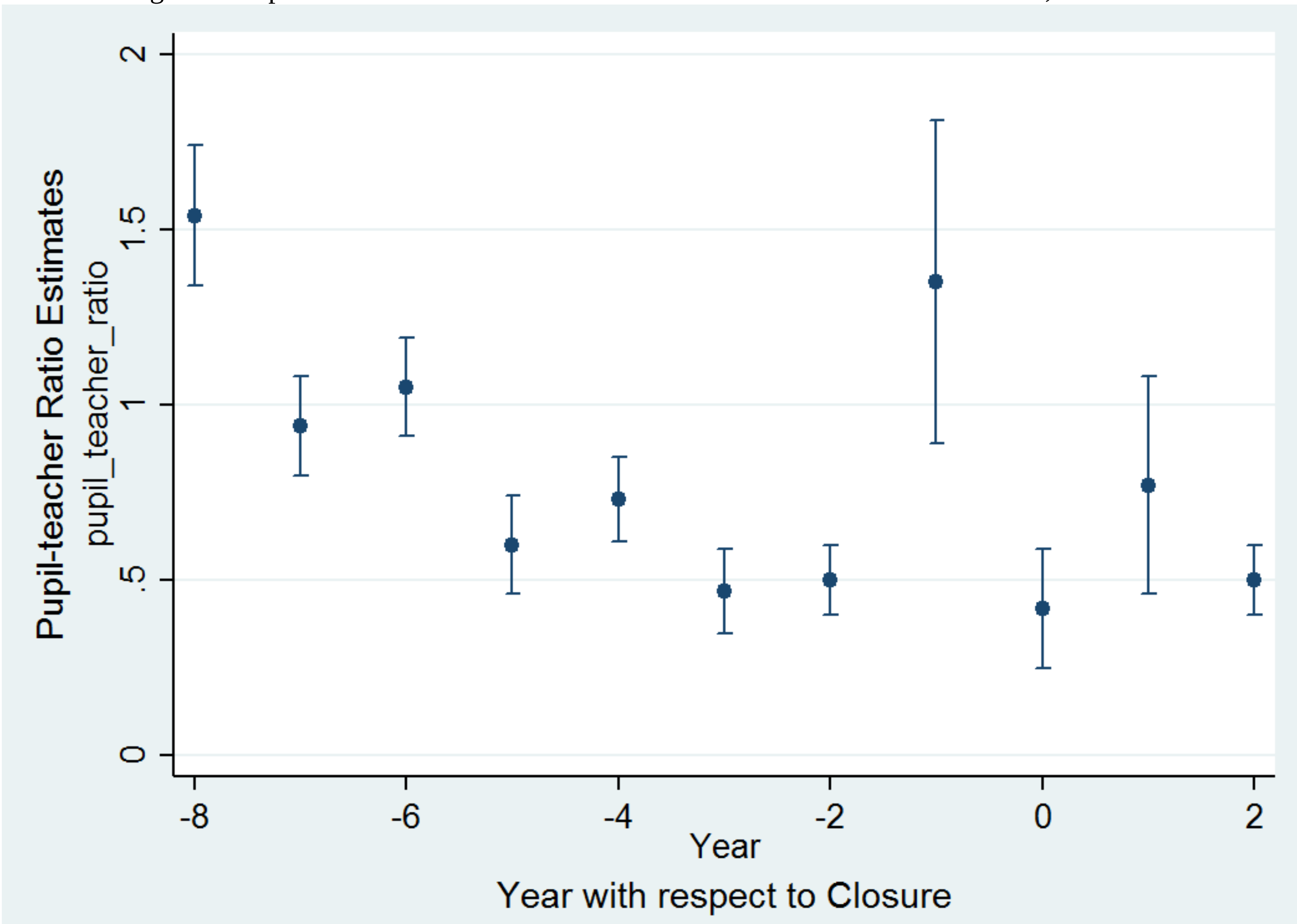


Figure 5: Point Estimates of the Total Number of Students and Standard Errors from Table 7, Column 2

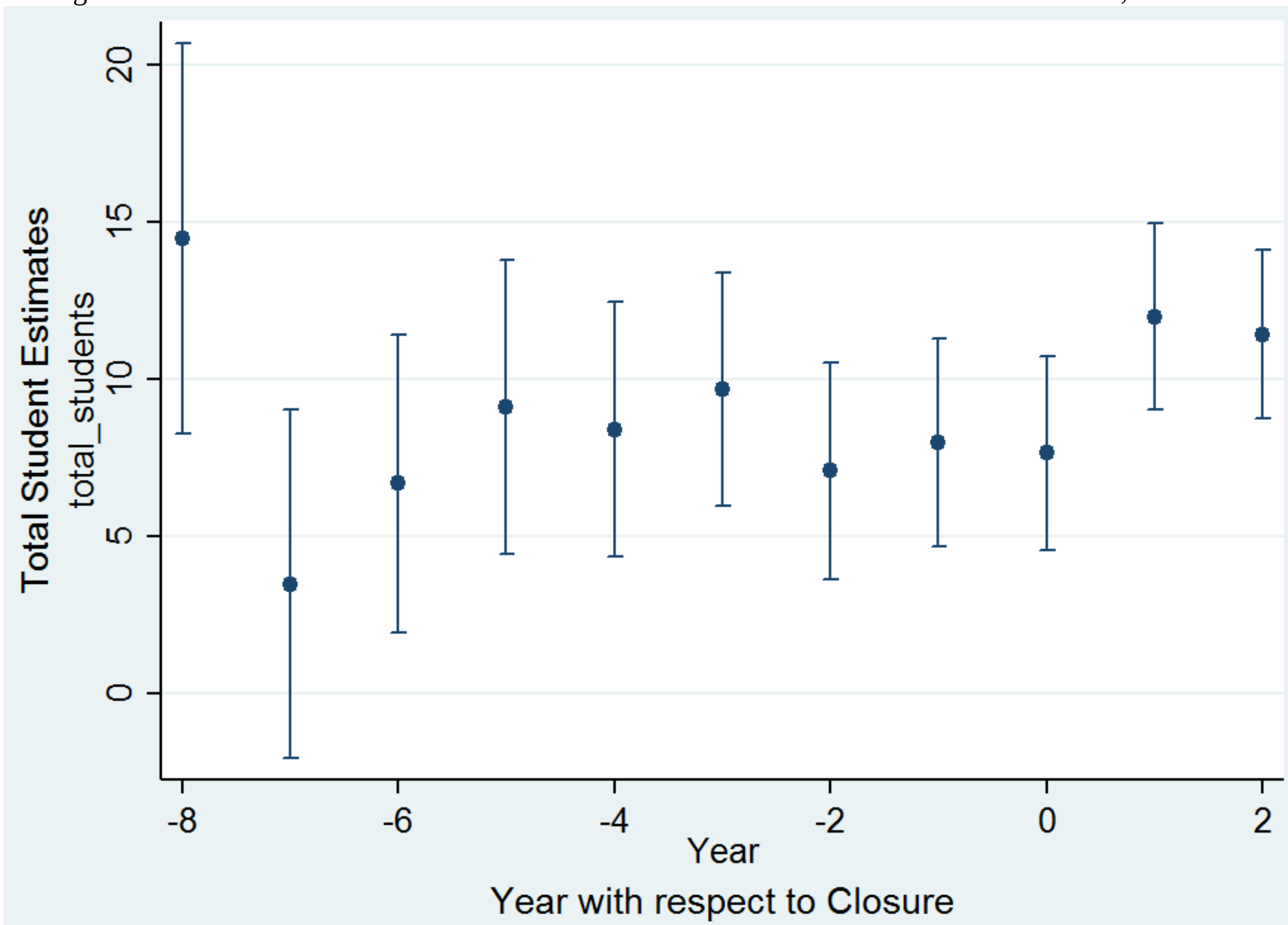
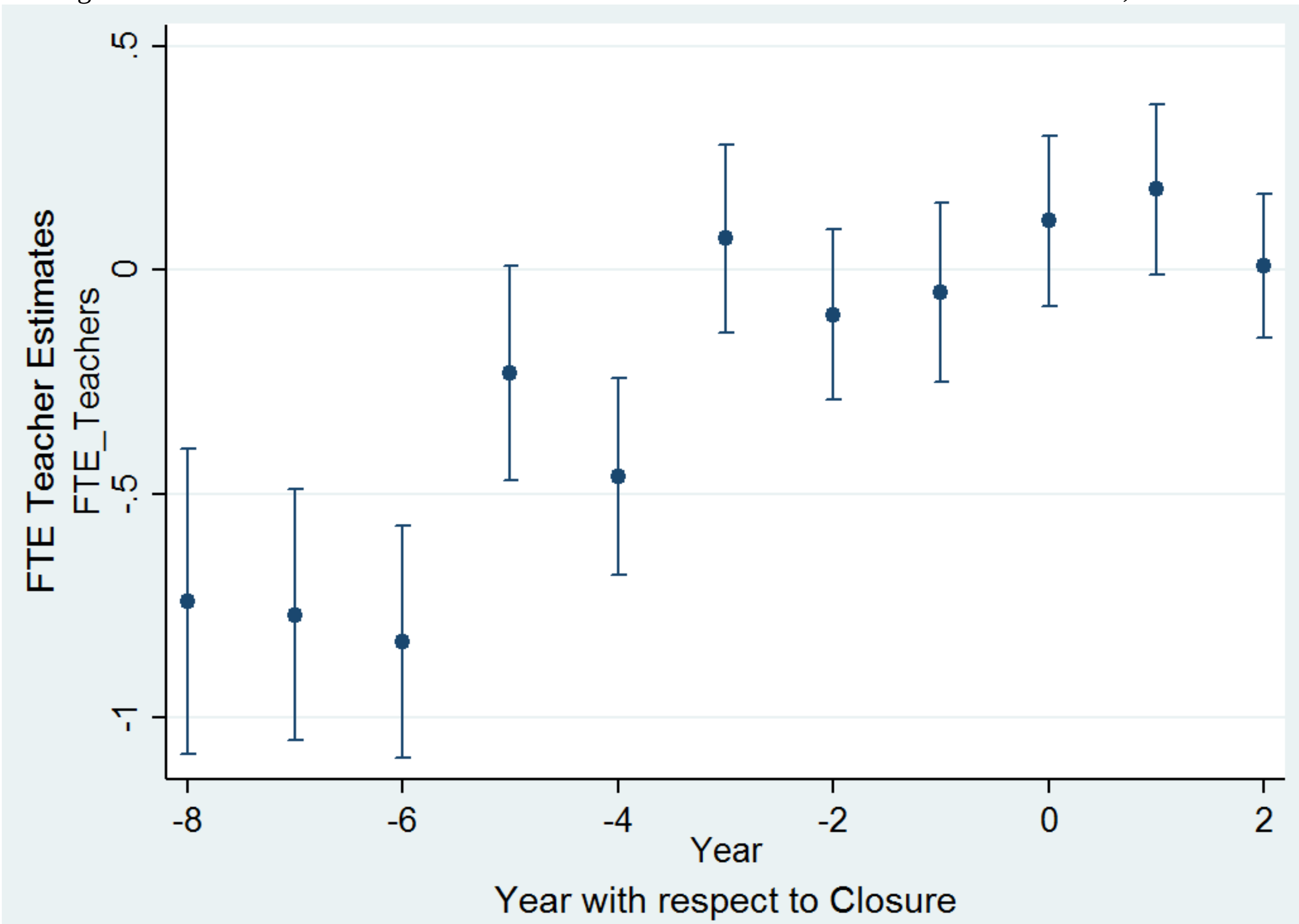


Figure 6: Point Estimates of the Number of FTE Teachers and Standard Errors from Table 7, Column 3



CHAPTER SIX

CONCLUSION

The impact of military base closures on the American education system has largely been overlooked by past research. More specifically, no prior research has studied the effects of base closures on the pupil-teacher ratios of nearby schools up to this point. Using NCES data as well as publicly available data regarding each military base, this thesis characterized the effects of military base closures (carried out by the BRAC process) on the pupil-teacher ratio, the total number of students, and the total number of full-time equivalent teachers. The analysis modeled the actual timing of the base closure process in three different ways so as not to overlook any possibilities. In addition, the regression models included demographic and locale controls and also controlled for year and school specific fixed effects.

There was a statistically significant relationship between military base closures and the pupil-teacher ratio when the closure process was modeled in both single and multiple year formats. Looking at (absolute) maximum estimates across the two modeling formats, a nearby elementary school's pupil-teacher ratio changed by -0.71 to 1.54 pupils on average. Both of these estimates were small relative to a standard deviation in the pupil-teacher ratio (8.5% of a standard deviation and 18.4%, respectively). The differing signs also indicate that military base closures have different kinds of effects on the pupil-teacher ratio depending on the frame of reference. Modeling the base closures as linear actions did not yield a statistically significant impact on the pupil-teacher ratio.

Focusing solely on the total number of students at elementary schools, it was estimated that the student populations at affected schools changed anywhere from -10.98 students to 14.48 students on average. These estimates were only 4.7% and 6.2% of a standard deviation in the number of students.

Finally, the analysis examined the number of FTE teachers at elementary schools. Military base closures were correlated with changes in the number of FTE teachers at nearby schools ranging from -0.83 to 0.30 teachers on average. The former of these two estimates was significant at the 1% confidence level but in terms of magnitude, only made up 6.1% of a standard deviation. The latter estimate was statistically insignificant.

In conclusion, the results indicate that the impacts of military base closures on the pupil-teacher ratios, student populations, and teacher populations of nearby elementary schools are very real but also that they are small in magnitude. As such, policymakers do not need to worry about the effects of military base closures on the surrounding education system insofar as the aforementioned populations and measures are concerned. The findings herein conform to those of the majority of the research that has focused on military base closures, namely in that the effects of closures are minor and that communities can recover from them.

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APPENDICES

APPENDIX A

MAJOR BASE CLOSURES BY BRAC ROUND

Military Base	State	Closure Year	BRAC Round
Kulis Air Guard Station	Alaska	2011	2005
Riverbank Army Ammunition Plant	California	2010	2005
Onizuka Air Force Station	California	2010	2005
Fort Gillem	Georgia	2011	2005
Naval Air Station Atlanta	Georgia	2009	2005
Fort McPherson	Georgia	2011	2005
Newport Chemical Depot	Indiana	2010	2005
Kansas Army Ammunition Plant	Kansas	2008	2005
Naval Air Station Brunswick	Maine	2011	2005
Selfridge Army Activity	Michigan	2008	2005
Mississippi Army Ammunition Plant	Mississippi	2009	2005
Naval Station Pascagoula	Mississippi	2006	2005
Fort Monmouth	New Jersey	2011	2005
Umatilla Chemical Depot	Oregon	2012	2005
Naval Air Station Willow Grove	Pennsylvania	2011	2005
Lone Star Army Ammunition Plant	Texas	2009	2005
Naval Station Ingleside	Texas	2010	2005
Brooks City Base	Texas	2011	2005
Deseret Chemical Depot	Utah	2013	2005
Fort Monroe	Virginia	2011	2005
General Mitchell ARS	Wisconsin	2008	2005
Fort McClellan	Alabama	1999	1995
Naval Air Facility Adak	Alaska	1998	1995
Fort Chaffee	Arkansas	1997	1995
Oakland Army Base	California	2001	1995
Naval Shipyard Long Beach	California	1997	1995
McClellan Air Force Base	California	2001	1995
Ontario International Airport Air Guard Station	California	1997	1995
Fleet Industrial Supply Center	California	1998	1995
Fitzsimons Army Medical Center	Colorado	2000	1995
Savanna Army Depot Activity	Illinois	2001	1995
Naval Air Warfare Center, Aircraft Division, Indianapolis	Indiana	2000	1995
Naval Surface Warfare Center, Crane Division Detachment, Louisvillle	Kentucky	1997	1995
Fort Ritchie	Maryland	1998	1995

Naval Surface Warfare Center, Dahlgren Division Detachment, White Oak	Maryland	1997	1995
Fort Holabird	Maryland	1996	1995
Naval Air Station South Weymouth	Massachusetts	1997	1995
Bayonne Military Ocean Terminal	New Jersey	2001	1995
Seneca Army Depot	New York	2001	1995
Roslyn Air Guard Station	New York	1997	1995
Fort Indiantown Gap	Pennsylvania	1998	1995
Naval Air Warfare Center, Aircraft Division, Warminster	Pennsylvania	1997	1995
Defense Distribution Depot Memphis	Tennessee	1997	1995
Bergstrom Air Reserve Base	Texas	1997	1995
Reese Air Force Base	Texas	1997	1995
Defense Distribution Depot Ogden	Utah	1997	1995
Fort Pickett	Virginia	1997	1995
Naval Station Mobile	Alabama	1994	1993
Mare Island Naval Shipyard	California	1996	1993
Marine Corps Air Station El Toro	California	1999	1993
Naval Air Station Alameda	California	1997	1993
Naval Aviation Depot Alameda	California	1997	1993
Naval Hospital Oakland	California	1996	1993
Naval Station Treasure Island	California	1997	1993
Naval Supply Center Oakland	California	1998	1993
Naval Training Center San Diego	California	1997	1993
Naval Training Center Orlando	Florida	1998	1993
Naval Air Station Cecil Field	Florida	1999	1993
Naval Aviation Depot Pensacola	Florida	1996	1993
Homestead Air Force Base	Florida	1994	1993
Naval Air Station Barbers Point	Hawaii	1999	1993
Naval Air Station Glenview	Illinois	1995	1993
O'Hare International Airport Air Force Reserve Station	Illinois	1999	1993
Naval Electronic Systems Engineering Center, St. Inigoes	Maryland	1997	1993
K.I. Sawyer Air Force Base	Michigan	1995	1993
Naval Station Staten Island	New York	1994	1993
Newark Air Force Base	Ohio	1996	1993
Defense Personnel Support Center	Pennsylvania	1999	1993

Charleston Naval Shipyard	South Carolina	1996	1993
Naval Station Dallas	Texas	1998	1993
Naval Aviation Depot Norfolk	Virginia	1997	1993
Vint Hill Farms	Virginia	1997	1993
Williams Air Force Base	Arizona	1993	1991
Eaker Air Force Base	Arkansas	1992	1991
Fort Ord	California	1994	1991
Sacramento Army Depot	California	1994	1991
Hunters Point Annex to Naval Station Treasure Island	California	1994	1991
Marine Corps Air Station Tustin	California	1999	1991
Naval Air Station Moffett Field	California	1994	1991
Naval Station Long Beach	California	1994	1991
Naval Electronic Systems Engineering Center, San Diego	California	1994	1991
Castle Air Force Base	California	1995	1991
Lowry Air Force Base	Colorado	1994	1991
Fort Benjamin Harrison	Indiana	1995	1991
Grissom Air Force Base	Indiana	1994	1991
England Air Force Base	Louisiana	1992	1991
Loring Air Force Base	Maine	1994	1991
Fort Devens	Massachusetts	1996	1991
Wurtsmith Air Force Base	Michigan	1993	1991
Richards-Gebaur Air Reserve Station	Missouri	1994	1991
Rickenbacker Air Guard Base	Ohio	1994	1991
Naval Station Philadelphia	Pennsylvania	1995	1991
Myrtle Beach Air Force Base	South Carolina	1993	1991
Naval Air Station Chase Field	Texas	1993	1991
Bergstrom Air Force Base	Texas	1993	1991
Carswell Air Force Base	Texas	1993	1991
Naval Station Puget Sound	Washington	1995	1991
George Air Force Base	California	1992	1988
Mather Air Force Base	California	1993	1988
Norton Air Force Base	California	1994	1988
Presidio of San Francisco	California	1994	1988
Chanute Air Force Base	Illinois	1993	1988
Fort Sheridan	Illinois	1993	1988
Jefferson Proving Ground	Indiana	1994	1988

Lexington-Bluegrass Army Depot	Kentucky	1995	1988
Pease Air Force Base	New Hampshire	1991	1988
Naval Station New York, Brooklyn	New York	1993	1988
Naval Hospital Philadelphia	Pennsylvania	1993	1988
Fort Douglas	Utah	1991	1988

APPENDIX B

REGRESSION PROGRESSIONS BY MODEL

Table 9: Regression Output with Pupil-teacher Ratio as the Dependent Variable and Single Year Treatment Vectors

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Single Year Treatment in	3.22***	2.39***	2.31***	2.07***	1.54***
Year T-8	(0.36)	(0.33)	(0.32)	(0.31)	(0.20)
Single Year Treatment in	2.74***	1.91***	1.74***	1.45***	0.94***
Year T-7	(0.27)	(0.25)	(0.24)	(0.24)	(0.14)
Single Year Treatment in	2.31***	1.58***	1.42***	1.19***	1.05***
Year T-6	(0.23)	(0.22)	(0.21)	(0.20)	(0.14)
Single Year Treatment in	2.12***	1.33***	1.24***	1.12***	0.60***
Year T-5	(0.19)	(0.18)	(0.17)	(0.16)	(0.14)
Single Year Treatment in	2.16***	1.36***	1.23***	1.11***	0.73***
Year T-4	(0.18)	(0.17)	(0.16)	(0.16)	(0.12)
Single Year Treatment in	2.42***	1.57***	1.39***	1.12***	0.47***
Year T-3	(0.16)	(0.15)	(0.14)	(0.14)	(0.12)
Single Year Treatment in	2.44***	1.73***	1.52***	1.29***	0.50***
Year T-2	(0.16)	(0.15)	(0.15)	(0.14)	(0.10)
Single Year Treatment in	3.30***	2.73***	2.55***	2.43***	1.35***
Year T-1	(0.54)	(0.54)	(0.54)	(0.54)	(0.46)
Single Year Treatment in	2.05***	1.55***	1.40***	1.32***	0.42**
Year T	(0.17)	(0.16)	(0.16)	(0.16)	(0.17)
Single Year Treatment in	2.29***	1.95***	1.78***	1.65***	0.77**
Year T+1	(0.43)	(0.43)	(0.43)	(0.43)	(0.31)
Single Year Treatment in	1.95***	1.60***	1.33***	1.43***	0.50***
Year T+2	(0.14)	(0.14)	(0.14)	(0.13)	(0.10)
Time Trend		-0.15***	-0.15***		
		(0.00)	(0.00)		
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					60,475
Observations	773,969	773,969	773,969	773,969	773,969

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The single year treatment vector is a binary variable equal to one only in the official year of a base's closure. It is equal to zero in all other years.

Table 10: Regression Output with Pupil-teacher Ratio as the Dependent Variable and a Typical Treatment Vector

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Treatment (Typical)	0.88***	1.23***	0.94***	1.04***	-0.71***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.12)
Time Trend		-0.15***	-0.15***		
		(0.00)	(0.00)		
% of Students that are Hispanic			0.02***	0.03***	-0.00
			(0.00)	(0.00)	(0.00)
% of Students that are Black			-0.01***	-0.01***	-0.01***
			(0.00)	(0.00)	(0.00)
% of Students Eligible for Free Lunches			-0.02***	-0.02***	-0.02***
			(0.00)	(0.00)	(0.00)
Urban Locale Dummy			0.69***	0.60***	
			(0.03)	(0.03)	
Suburban Locale Dummy			0.54***	0.44***	
			(0.03)	(0.03)	
Rural Locale Dummy			-0.80***	-0.83***	
			(0.03)	(0.03)	
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					60,475
Observations	773,969	773,969	773,969	773,969	773,969

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The typical treatment vector is a binary variable equal to one in the year of a base closure and all following years and is equal to zero in all years prior to a closure.

Table 11: Regression Output with Pupil-teacher Ratio as the Dependent Variable and a Linear Treatment Vector

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Treatment (Linear)	-0.16***	0.02	-0.02	0.09***	-0.21
	(0.02)	(0.02)	(0.02)	(0.03)	(0.23)
Linear Treatment Squared	-0.03***	-0.03***	-0.03***	-0.02***	-0.01**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Time Trend		-0.31***	-0.29***		
		(0.02)	(0.02)		
% of Students that are Hispanic			0.02***	0.02***	0.01
			(0.01)	(0.01)	(0.02)
% of Students that are Black			-0.04***	-0.03***	0.01
			(0.00)	(0.00)	(0.02)
% of Student Eligible for Free Lunches			-0.01**	-0.02***	0.02
			(0.00)	(0.00)	(0.01)
Urban Locale Dummy			0.83***	0.57***	
			(0.21)	(0.22)	
Suburban Locale Dummy			-0.99***	-1.30***	
			(0.20)	(0.20)	
Rural Locale Dummy			-2.07***	-2.35***	
			(0.33)	(0.34)	
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					1,994
Observations	16,170	16,170	16,170	16,170	16,170

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The linear treatment vector is a binary variable equal to unity in the year of a base closure, -1 and 1 in the years before and after a closure, continuing out to -5 and 5.

Table 12: Regression Output with Total # of Students as the Dependent Variable and Single Year Treatment Vectors

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Single Year Treatment in Year T-8	58.49***	46.95***	16.51	21.95*	14.48**
	(13.08)	(12.93)	(12.37)	(12.37)	(6.22)
Single Year Treatment in Year T-7	60.91***	49.37***	18.39*	22.32**	3.48
	(10.68)	(10.58)	(10.02)	(10.00)	(5.55)
Single Year Treatment in Year T-6	50.40***	40.28***	8.78	11.54	6.68
	(9.22)	(9.17)	(8.71)	(8.67)	(4.73)
Single Year Treatment in Year T-5	40.83***	29.86***	2.45	5.10	9.12*
	(8.36)	(8.35)	(8.07)	(7.96)	(4.68)
Single Year Treatment in Year T-4	43.70***	32.61***	-0.30	-0.25	8.41**
	(7.28)	(7.26)	(7.00)	(6.95)	(4.06)
Single Year Treatment in Year T-3	53.98***	42.16***	5.17	4.95	9.68***
	(6.82)	(6.78)	(6.43)	(6.41)	(3.72)
Single Year Treatment in Year T-2	42.98***	33.12***	-3.16	-4.88	7.08**
	(6.21)	(6.18)	(5.86)	(5.84)	(3.46)
Single Year Treatment in Year T-1	41.16***	33.28***	-1.96	-6.73	7.98**
	(6.11)	(6.06)	(5.73)	(5.72)	(3.32)
Single Year Treatment in Year T	40.91***	34.07***	-1.68	-7.45	7.65**
	(6.23)	(6.19)	(5.87)	(5.87)	(3.09)
Single Year Treatment in Year T+1	43.30***	38.65***	0.78	-6.47	11.99***
	(6.19)	(6.16)	(5.79)	(5.79)	(2.97)
Single Year Treatment in Year T+2	50.00***	45.11***	8.63	0.83	11.43***
	(6.53)	(6.50)	(6.26)	(6.25)	(2.68)
Time Trend		-2.01***	-3.05***		
		(0.04)	(0.04)		
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					60,475
Observations	773,969	773,969	773,969	773,969	773,969

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The single year treatment vector is a binary variable equal to one only in the official year of a base's closure. It is equal to zero in all other years.

Table 13: Regression Output with Total # of Students as the Dependent Variable and a Typical Treatment Vector

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Treatment (Typical)	24.81***	29.75***	-15.25***	-15.35***	-10.98***
	(1.57)	(1.57)	(1.54)	(1.54)	(3.22)
Time Trend		-2.11***	-3.04***		
		(0.04)	(0.04)		
% of Students that are Hispanic			2.74***	2.77***	1.07***
			(0.02)	(0.02)	(0.06)
% of Students that are Black			0.92***	0.95***	-0.22***
			(0.01)	(0.01)	(0.07)
% of Students Eligible for Free Lunches			-1.04***	-1.10***	-0.61***
			(0.02)	(0.02)	(0.03)
Urban Locale Dummy			86.87***	86.68***	
			(0.74)	(0.74)	
Suburban Locale Dummy			119.53***	118.87***	
			(0.72)	(0.72)	
Rural Locale Dummy			6.86***	6.96***	
			(0.78)	(0.78)	
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					60,475
Observations	773,969	773,969	773,969	773,969	773,969

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The typical treatment vector is a binary variable equal to one in the year of a base closure and all following years and is equal to zero in all years prior to a closure.

Table 14: Regression Output with Total # of Students as the Dependent Variable and a Linear Treatment Vector

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Treatment (Linear)	-0.667	2.899***	0.973*	-2.809***	-5.852**
	(0.510)	(0.535)	(0.508)	(0.621)	(2.544)
Linear Treatment Squared	-0.358**	-0.393***	-0.296**	0.311*	-0.109
	(0.149)	(0.148)	(0.142)	(0.161)	(0.0967)
Time Trend		-6.133***	-6.484***		
		(0.325)	(0.316)		
% of Students that are Hispanic			2.908***	2.892***	0.891***
			(0.101)	(0.101)	(0.332)
% of Students that are Black			-0.210**	-0.227**	-0.0351
			(0.0894)	(0.0903)	(0.342)
% of Students Eligible for Free Lunches			0.0385	0.00867	-0.191
			(0.0908)	(0.0923)	(0.134)
Urban Locale Dummy			43.19***	49.69***	
			(5.505)	(5.496)	
Suburban Locale Dummy			74.04***	79.04***	
			(5.866)	(5.872)	
Rural Locale Dummy			-42.43***	-38.31***	
			(12.12)	(12.24)	
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					1,994
Observations	16,170	16,170	16,170	16,170	16,170

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The linear treatment vector is a binary variable equal to unity in the year of a base closure, -1 and 1 in the years before and after a closure, continuing out to -5 and 5.

Table 15: Regression Output with Number of FTE Teachers as the Dependent Variable and Single Year Treatment Vectors

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Single Year Treatment in	-0.95	-0.15	-2.00***	-1.23*	-0.74**
Year T-8	(0.70)	(0.70)	(0.64)	(0.64)	(0.34)
Single Year Treatment in	-0.53	0.27	-1.45***	-0.73	-0.77***
Year T-7	(0.57)	(0.57)	(0.53)	(0.53)	(0.28)
Single Year Treatment in	-0.35	0.35	-1.38***	-0.86*	-0.83***
Year T-6	(0.52)	(0.52)	(0.48)	(0.48)	(0.26)
Single Year Treatment in	-0.96**	-0.21	-1.84***	-1.50***	-0.23
Year T-5	(0.45)	(0.45)	(0.43)	(0.43)	(0.24)
Single Year Treatment in	-0.83**	-0.06	-1.91***	-1.67***	-0.46**
Year T-4	(0.40)	(0.40)	(0.38)	(0.38)	(0.22)
Single Year Treatment in	-0.70*	0.12	-1.84***	-1.49***	0.07
Year T-3	(0.36)	(0.36)	(0.34)	(0.34)	(0.21)
Single Year Treatment in	-1.17***	-0.49	-2.36***	-2.11***	-0.10
Year T-2	(0.34)	(0.34)	(0.33)	(0.32)	(0.19)
Single Year Treatment in	-1.04***	-0.49	-2.35***	-2.35***	-0.05
Year T-1	(0.34)	(0.33)	(0.32)	(0.32)	(0.20)
Single Year Treatment in	-0.41	0.07	-1.88***	-1.99***	0.11
Year T	(0.36)	(0.36)	(0.34)	(0.34)	(0.19)
Single Year Treatment in	-0.34	-0.02	-2.02***	-2.14***	0.18
Year T+1	(0.36)	(0.35)	(0.33)	(0.33)	(0.19)
Single Year Treatment in	-0.20	0.14	-1.64***	-2.04***	0.01
Year T+2	(0.36)	(0.36)	(0.35)	(0.35)	(0.16)
Time Trend		0.14***	0.09***		
		(0.00)	(0.00)		
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					60,475
Observations	773,969	773,969	773,969	773,969	773,969

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The single year treatment vector is a binary variable equal to one only in the official year of a base's closure. It is equal to zero in all other years.

Table 16: Regression Output with Number of FTE Teachers as the Dependent Variable and a Typical Treatment Vector

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Treatment (Typical)	0.68***	0.36***	-1.93***	-2.06***	0.30
	(0.09)	(0.09)	(0.09)	(0.09)	(0.19)
Time Trend		0.14***	0.09***		
		(0.00)	(0.00)		
% of Students that are Hispanic			0.13***	0.12***	0.10***
			(0.00)	(0.00)	(0.00)
% of Students that are Black			0.09***	0.09***	0.02***
			(0.00)	(0.00)	(0.00)
% of Students Eligible for Free Lunches			-0.05***	-0.04***	-0.02***
			(0.00)	(0.00)	(0.00)
Urban Locale Dummy			3.91***	4.02***	
			(0.05)	(0.05)	
Suburban Locale Dummy			5.95***	6.07***	
			(0.04)	(0.04)	
Rural Locale Dummy			1.05***	1.09***	
			(0.05)	(0.05)	
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					60,475
Observations	773,969	773,969	773,969	773,969	773,969

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The typical treatment vector is a binary variable equal to one in the year of a base closure and all following years and is equal to zero in all years prior to a closure.

Table 17: Regression Output with Number of FTE Teachers as the Dependent Variable and a Linear Treatment Vector

VARIABLES	(1) OLS	(2) OLS 2	(3) OLS 3	(4) FE Model 1	(5) Full FE Model
Treatment (Linear)	0.21***	0.07**	0.02	-0.27***	-0.14**
	(0.03)	(0.03)	(0.03)	(0.04)	(0.06)
Linear Treatment Squared	0.01	0.01	0.02**	0.03***	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Time Trend		0.24***	0.17***		
		(0.02)	(0.02)		
% of Students that are Hispanic			0.16***	0.15***	0.06***
			(0.01)	(0.01)	(0.02)
% of Students that are Black			0.07***	0.06***	-0.03*
			(0.01)	(0.01)	(0.02)
% of Students Eligible for Free Lunches			0.00	0.01**	-0.01
			(0.01)	(0.01)	(0.01)
Urban Locale Dummy			1.20***	1.81***	
			(0.31)	(0.31)	
Suburban Locale Dummy			5.59***	6.23***	
			(0.34)	(0.34)	
Rural Locale Dummy			0.36	0.91	
			(0.79)	(0.80)	
Demographic Variables	NO	NO	YES	YES	YES
Locale Controls	NO	NO	YES	YES	YES
Year FE	NO	NO	NO	YES	YES
School FE	NO	NO	NO	NO	YES
Number of uniqueid					1,994
Observations	16,170	16,170	16,170	16,170	16,170

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The linear treatment vector is a binary variable equal to unity in the year of a base closure, -1 and 1 in the years before and after a closure, continuing out to -5 and 5.

APPENDIX C

REGRESSION OUTPUT BY LOCALE TYPE

Table 18. Regression Output from Main Model, Population Limited to Urban Schools

Independent Variables	Dependent Variables (1) Pupil-teacher ratio	(2) Total # of Students	(3) Total FTE Teachers
Single Year Treatment in Year T-8	1.79***	13.97	-1.23**
	(0.32)	(9.38)	(0.51)
Single Year Treatment in Year T-7	1.19***	5.26	-1.25***
	(0.20)	(7.78)	(0.40)
Single Year Treatment in Year T-6	1.11***	10.14	-0.94***
	(0.20)	(6.65)	(0.35)
Single Year Treatment in Year T-5	0.87***	16.52***	-0.26
	(0.18)	(6.03)	(0.31)
Single Year Treatment in Year T-4	1.16***	15.04***	-0.55*
	(0.18)	(5.44)	(0.30)
Single Year Treatment in Year T-3	0.74***	12.41***	-0.21
	(0.14)	(4.76)	(0.26)
Single Year Treatment in Year T-2	0.64***	12.03***	-0.10
	(0.12)	(4.38)	(0.24)
Single Year Treatment in Year T-1	2.40***	11.99***	-0.21
	(0.82)	(4.23)	(0.25)
Single Year Treatment in Year T	0.67**	8.09**	-0.19
	(0.30)	(4.08)	(0.24)
Single Year Treatment in Year T+1	1.34**	10.33***	-0.29
	(0.54)	(3.84)	(0.23)
Single Year Treatment in Year T+2	0.73***	11.65***	-0.05
	(0.14)	(3.72)	(0.22)
Demographic Variables (% Hispanic, % Black, % Free Lunch Eligible)	YES	YES	YES
Locale Controls (Urban, Suburban, and Rural)	YES	YES	YES
Year FE	YES	YES	YES
School FE	YES	YES	YES
Observations	211,703	211,703	211,703
R-squared	0.02	0.05	0.05
Number of uniqueid	14,540	14,540	14,540

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The treatment vector is equal to unity in the year of a base closure and zero in all other years. Lagged and led versions are also added to the model as specified above.

Table 19: Urban Specific Regression Results using the Linear and Typical Treatment Vectors

	Panel 1: Typical Treatment Vector			Panel 2: Linear Treatment Vector		
Description:	Equal to unity in the year of a base closure and all successive years, zero in all years prior to closure.			Equal to zero in the year of a base closure, -1 and 1 in the year before and year after the closure, and this trend continues out to -6 and 6.		
	(1) Pupil-teacher ratio	(2) Total Number of Students	(3) Number of FTE Teachers	(4) Pupil-teacher ratio	(5) Total Number of Students	(6) Number of FTE Teachers
Treatment	-0.80***	-14.23***	0.20	-0.47	-8.96*	-0.06
	(0.19)	(4.53)	(0.28)	(0.51)	(4.59)	(0.12)
% of Students that are Hispanic	0.00	1.24***	0.09***	0.03	1.18***	0.06***
	(0.00)	(0.10)	(0.01)	(0.03)	(0.40)	(0.02)
% of Students that are Black	-0.00	-0.29**	-0.00	0.01	0.15	-0.02
	(0.00)	(0.11)	(0.01)	(0.03)	(0.37)	(0.02)
% of Students Eligible for a Free Lunch Program	-0.01***	-0.39***	-0.00	0.02	-0.27**	-0.02**
	(0.00)	(0.05)	(0.00)	(0.02)	(0.13)	(0.01)
Linear Treatment Squared				-0.01***	-0.10	-0.01
				(0.01)	(0.14)	(0.01)
Demographic Variables	YES	YES	YES	YES	YES	YES
Locale Controls (Urban, Suburban, Rural)	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
School FE	YES	YES	YES	YES	YES	YES
Observations	211,703	211,703	211,703	8,639	8,639	8,639
R-squared	0.02	0.05	0.05	0.05	0.07	0.18
Number of uniqueid	14,540	14,540	14,540	1,015	1,015	1,015

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 20. Regression Output from Main Model, Population Limited to Suburban Schools

Independent Variables	Dependent Variables (1) Pupil-teacher ratio	(2) Total # of Students	(3) Total FTE Teachers
Single Year Treatment in Year T-8	0.65***	-8.02	-0.61
	(0.21)	(10.59)	(0.65)
Single Year Treatment in Year T-7	0.08	-27.28**	-0.69
	(0.25)	(11.47)	(0.56)
Single Year Treatment in Year T-6	0.40*	-14.69	-0.76
	(0.23)	(9.09)	(0.56)
Single Year Treatment in Year T-5	-0.14	-24.67**	-0.70
	(0.19)	(10.32)	(0.57)
Single Year Treatment in Year T-4	0.22	-12.43	-1.02**
	(0.15)	(7.79)	(0.43)
Single Year Treatment in Year T-3	0.09	-5.43	0.17
	(0.22)	(7.27)	(0.45)
Single Year Treatment in Year T-2	0.25	-11.42*	-0.40
	(0.19)	(6.85)	(0.41)
Single Year Treatment in Year T-1	-0.05	-9.17	-0.23
	(0.19)	(6.34)	(0.41)
Single Year Treatment in Year T	0.04	-3.88	0.23
	(0.14)	(5.60)	(0.39)
Single Year Treatment in Year T+1	0.14	5.44	0.43
	(0.14)	(5.70)	(0.38)
Single Year Treatment in Year T+2	0.24*	11.55**	0.47
	(0.13)	(4.84)	(0.31)
Demographic Variables (% Hispanic, % Black, % Free Lunch Eligible)	YES	YES	YES
Locale Controls (Urban, Suburban, and Rural)	YES	YES	YES
Year FE	YES	YES	YES
School FE	YES	YES	YES
Observations	267,707	267,707	267,707
R-squared	0.03	0.03	0.07
Number of uniqueid	17,674	17,674	17,674

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The treatment vector is equal to unity in the year of a base closure and zero in all other years. Lagged and led versions are also added to the model as specified above.

Table 21: Suburban Specific Regression Results using the Linear and Typical Treatment Vectors

	Panel 1: Typical Treatment Vector			Panel 2: Linear Treatment Vector		
Description:	Equal to unity in the year of a base closure and all successive years, zero in all years prior to closure.			Equal to zero in the year of a base closure, -1 and 1 in the year before and year after the closure, and this trend continues out to -6 and 6.		
	(1) Pupil-teacher ratio	(2) Total Number of Students	(3) Number of FTE Teachers	(4) Pupil-teacher ratio	(5) Total Number of Students	(6) Number of FTE Teachers
Treatment	-0.37***	11.71**	1.10***	0.07	0.55	-0.05
	(0.12)	(5.55)	(0.34)	(0.06)	(2.24)	(0.05)
% of Students that are Hispanic	-0.01	0.98***	0.11***	-0.05***	-0.77	0.08
	(0.00)	(0.10)	(0.01)	(0.01)	(0.91)	(0.05)
% of Students that are Black	-0.01**	0.06	0.04***	-0.00	-1.80*	-0.08*
	(0.01)	(0.12)	(0.01)	(0.01)	(1.02)	(0.05)
% of Students Eligible for a Free Lunch Program	-0.01***	-0.79***	-0.03***	0.02*	-0.15	-0.00
	(0.00)	(0.06)	(0.00)	(0.01)	(0.35)	(0.02)
Linear Treatment Squared				-0.01***	-0.60**	-0.02
				(0.01)	(0.24)	(0.01)
Demographic Variables	YES	YES	YES	YES	YES	YES
Locale Controls (Urban, Suburban, Rural)	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
School FE	YES	YES	YES	YES	YES	YES
Observations	267,707	267,707	267,707	4,789	4,789	4,789
R-squared	0.03	0.03	0.07	0.25	0.03	0.24
Number of uniqueid	17,674	17,674	17,674	599	599	599

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 22. Regression Output from Main Model, Population Limited to Rural Schools

Independent Variables	Dependent Variables (1) Pupil-teacher ratio	(2) Total # of Students	(3) Total FTE Teachers
Single Year Treatment in Year T-8	-0.10	-15.20	-0.68
	(0.24)	(11.92)	(0.86)
Single Year Treatment in Year T-7	0.79	-32.06***	-3.16***
	(1.05)	(8.11)	(1.11)
Single Year Treatment in Year T-6	0.74	-33.74***	-3.00***
	(0.47)	(11.51)	(0.75)
Single Year Treatment in Year T-5	0.47	-21.74	-1.97**
	(0.64)	(15.95)	(0.96)
Single Year Treatment in Year T-4	-0.60	-40.67	-1.69
	(0.71)	(32.20)	(1.69)
Single Year Treatment in Year T-3	-1.21*	-52.32*	-1.20
	(0.70)	(27.15)	(1.30)
Single Year Treatment in Year T-2	0.09	-29.88	-1.56
	(0.62)	(26.73)	(1.21)
Single Year Treatment in Year T-1	-0.44	-35.05	-1.37
	(0.71)	(25.01)	(1.15)
Single Year Treatment in Year T	-0.45	-6.36	0.33
	(0.46)	(19.18)	(0.88)
Single Year Treatment in Year T+1	-0.23	-11.48	-0.13
	(0.46)	(16.25)	(0.91)
Single Year Treatment in Year T+2	-0.10	-35.79**	-1.86*
	(0.60)	(17.16)	(0.98)
Demographic Variables (% Hispanic, % Black, % Free Lunch Eligible)	YES	YES	YES
Locale Controls (Urban, Suburban, and Rural)	YES	YES	YES
Year FE	YES	YES	YES
School FE	YES	YES	YES
Observations	131,908	131,908	131,908
R-squared	0.02	0.03	0.04
Number of uniqueid	12,170	12,170	12,170

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The treatment vector is equal to unity in the year of a base closure and zero in all other years. Lagged and led versions are also added to the model as specified above.

Table 23: Rural Specific Regression Results using the Linear and Typical Treatment Vectors

	Panel 1: Typical Treatment Vector			Panel 2: Linear Treatment Vector		
Description:	Equal to unity in the year of a base closure and all successive years, zero in all years prior to closure.			Equal to zero in the year of a base closure, -1 and 1 in the year before and year after the closure, and this trend continues out to -6 and 6.		
	(1) Pupil-teacher ratio	(2) Total Number of Students	(3) Number of FTE Teachers	(4) Pupil-teacher ratio	(5) Total Number of Students	(6) Number of FTE Teachers
Treatment	0.64*	30.32	0.59	-0.02	-5.65**	-0.34**
	(0.38)	(20.05)	(1.10)	(0.04)	(2.43)	(0.14)
% of Students that are Hispanic	0.01	1.47***	0.10***	0.07**	6.37**	0.40**
	(0.01)	(0.18)	(0.01)	(0.03)	(3.00)	(0.16)
% of Students that are Black	-0.03***	-0.39	0.03**	0.06	-2.46	-0.26**
	(0.01)	(0.25)	(0.01)	(0.06)	(2.71)	(0.12)
% of Students Eligible for a Free Lunch Program	-0.02***	-0.87***	-0.03***	0.00	-0.03	-0.00
	(0.00)	(0.07)	(0.00)	(0.03)	(0.88)	(0.04)
Linear Treatment Squared				0.01	0.23	0.01
				(0.02)	(0.88)	(0.05)
Demographic Variables	YES	YES	YES	YES	YES	YES
Locale Controls (Urban, Suburban, Rural)	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
School FE	YES	YES	YES	YES	YES	YES
Observations	131,908	131,908	131,908	220	220	220
R-squared	0.02	0.03	0.04	0.22	0.29	0.43
Number of uniqueid	12,170	12,170	12,170	35	35	35

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

APPENDIX D

REGRESSION OUTPUT USING CALIFORNIA SCHOOLS

Table 24. Regression Output from Main Model, Population Limited to California Schools

Independent Variables	Dependent Variables (1) Pupil-teacher ratio	(2) Total # of Students	(3) Total FTE Teachers
Single Year Treatment in Year T-8	0.50**	26.89***	1.42***
	(0.24)	(9.88)	(0.46)
Single Year Treatment in Year T-7	0.34*	10.27	0.56
	(0.18)	(8.52)	(0.37)
Single Year Treatment in Year T-6	0.38*	13.27*	0.64**
	(0.20)	(7.28)	(0.32)
Single Year Treatment in Year T-5	0.18	27.00***	1.27***
	(0.22)	(7.44)	(0.31)
Single Year Treatment in Year T-4	0.37*	18.31***	0.61**
	(0.21)	(6.36)	(0.28)
Single Year Treatment in Year T-3	0.20	12.44**	0.41
	(0.16)	(5.29)	(0.25)
Single Year Treatment in Year T-2	-0.05	10.45**	0.64***
	(0.12)	(5.03)	(0.23)
Single Year Treatment in Year T-1	0.13	14.53***	0.65***
	(0.12)	(4.88)	(0.22)
Single Year Treatment in Year T	0.58***	9.59**	0.13
	(0.22)	(4.54)	(0.22)
Single Year Treatment in Year T+1	0.08	8.23*	0.44**
	(0.12)	(4.21)	(0.22)
Single Year Treatment in Year T+2	0.10	7.94*	0.34
	(0.13)	(4.26)	(0.21)
Demographic Variables (% Hispanic, % Black, % Free Lunch Eligible)	YES	YES	YES
Locale Controls (Urban, Suburban, and Rural)	YES	YES	YES
Year FE	YES	YES	YES
School FE	YES	YES	YES
Observations	95,731	95,731	95,731
R-squared	0.13	0.10	0.27
Number of uniqueid	6,422	6,422	6,422

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). The treatment vector is equal to unity in the year of a base closure and zero in all other years. Lagged and led versions are also added to the model as specified above.

Table 25: Regression Results using the Linear and Typical Treatment Vectors, Population Limited to California Schools

	Panel 1: Typical Treatment Vector			Panel 2: Linear Treatment Vector		
Description:	Equal to unity in the year of a base closure and all successive years, zero in all years prior to closure.			Equal to zero in the year of a base closure, -1 and 1 in the year before and year after the closure, and this trend continues out to -6 and 6.		
	(1)	(2)	(3)	(4)	(5)	(6)
	Pupil-teacher ratio	Total Number of Students	Number of FTE Teachers	Pupil-teacher ratio	Total Number of Students	Number of FTE Teachers
Treatment	-0.08	-11.96**	-0.69***	-0.01	-6.93***	-0.31***
	(0.11)	(4.83)	(0.21)	(0.09)	(2.01)	(0.07)
% of Students that are Hispanic	-0.00	0.08	0.02***	-0.01	-0.40	0.03
	(0.00)	(0.14)	(0.01)	(0.01)	(0.52)	(0.02)
% of Students that are Black	0.01	0.22	-0.03**	0.02	0.25	-0.01
	(0.01)	(0.28)	(0.01)	(0.01)	(0.45)	(0.02)
% of Students Eligible for a Free Lunch Program	-0.00	-0.34***	-0.01***	0.00	0.08	0.01
	(0.00)	(0.08)	(0.00)	(0.01)	(0.15)	(0.01)
Linear Treatment Squared				0.00	-0.15	-0.01
				(0.00)	(0.14)	(0.01)
Demographic Variables	YES	YES	YES	YES	YES	YES
Locale Controls (Urban, Suburban, Rural)	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
School FE	YES	YES	YES	YES	YES	YES
Observations	95,731	95,731	95,731	6,882	6,882	6,882
R-squared	0.13	0.10	0.27	0.49	0.08	0.37
Number of uniqueid	6,422	6,422	6,422	706	706	706

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

APPENDIX E

MEASURING BASE CLOSURE IMPACTS ON DEMOGRAPHICS

Table 26: Regressing Demographic Variables on the Single Year Treatment Vectors

Independent Variables	Dependent Variables (1) % of Students Eligible for Free Lunches	(2) % of Students Hispanic	(3) % of Students Black
Single Year Treatment in Year T-8	0.27	-1.87***	2.34***
	(0.75)	(0.47)	(0.34)
Single Year Treatment in Year T-7	-1.45*	-2.70***	1.53***
	(0.78)	(0.48)	(0.33)
Single Year Treatment in Year T-6	1.34**	-2.15***	1.05***
	(0.64)	(0.43)	(0.33)
Single Year Treatment in Year T-5	1.25**	-3.12***	1.54***
	(0.59)	(0.46)	(0.37)
Single Year Treatment in Year T-4	2.93***	-3.12***	1.76***
	(0.44)	(0.41)	(0.34)
Single Year Treatment in Year T-3	2.92***	-2.04***	1.10***
	(0.36)	(0.32)	(0.29)
Single Year Treatment in Year T-2	1.39***	-2.18***	0.89***
	(0.37)	(0.32)	(0.28)
Single Year Treatment in Year T-1	2.20***	-2.03***	0.91***
	(0.36)	(0.31)	(0.26)
Single Year Treatment in Year T	1.45***	-1.56***	0.85***
	(0.39)	(0.29)	(0.26)
Single Year Treatment in Year T+1	2.90***	-1.17***	0.75***
	(0.37)	(0.27)	(0.24)
Single Year Treatment in Year T+2	1.94***	-0.80***	0.83***
	(0.29)	(0.22)	(0.19)
Locale Controls (Urban, Suburban, and Rural)	YES	YES	YES
Year FE	YES	YES	YES
School FE	YES	YES	YES
Observations	773,969	773,969	773,969
R-squared	0.27	0.37	0.03
Number of uniqueid	60,475	60,475	60,475

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 27: Regressing Demographic Variables on the Typical and Linear Treatment Vectors

	Panel 1: Typical Treatment Vector			Panel 2: Linear Treatment Vector		
Description:	Equal to unity in the year of a base closure and all successive years, zero in all years prior to closure.			Equal to zero in the year of a base closure, -1 and 1 in the year before and year after the closure, and this trend continues out to -6 and 6.		
	(1)	(2)	(3)	(4)	(5)	(6)
	% of Students Eligible for Free Lunches	% of Students Hispanic	% of Students Black	% of Students Eligible for Free Lunches	% of Students Hispanic	% of Students Black
Treatment	-0.65*	3.49***	-1.59***	-0.00	-0.13	0.02
	(0.34)	(0.33)	(0.29)	(0.27)	(0.41)	(0.12)
Linear Treatment Squared				-0.03**	0.00	-0.01
				(0.01)	(0.01)	(0.01)
Locale Controls (Urban, Suburban, Rural)	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
School FE	YES	YES	YES	YES	YES	YES
Observations	773,969	773,969	773,969	16,170	16,170	16,170
R-squared	0.27	0.37	0.03	0.16	0.36	0.02
Number of uniqueid	60,475	60,475	60,475	1,994	1,994	1,994

Cluster robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).