Does Closing Schools Close Doors? The Effect of High School Closings on Achievement and Attainment[1]

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Abstract

The idea that low-performing schools should be closed, either through market competition or government intervention, is now a central tenet of state and federal school reform efforts, yet little is known about the impacts of these closures. Most previous studies examine the effects of elementary school closings on test scores. This study furthers the literature by focusing on high school closures and examining several measures of both achievement and attainment. I utilize student level data from the Milwaukee Public School district and follow five freshman cohorts (2005-06 to 2009-10) as they progress through high school. During this time there were 33 school closures affecting these cohorts. I find that, on average, school closings cause a negative shock to students, lowering both their GPA and attendance. There is evidence that students bounce back over time, however, for many students, high school ends before the effects can completely be reversed. These closures also have long-run consequence both lowering the probability of high school graduation and college attendance.

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1. Introduction

School closures are now common across the United States, yet they are always controversial. Across the United States, 2,076 schools closed between the 2010-11 and the 2011-12 academic years forcing thousands of students to change schools (Common Core of Data). Chicago and Philadelphia's school districts made headlines recently after announcing the closure of 47 and 23 schools respectively, some of the largest single closures in US history.[3] In Chicago, the strong opposition to these closures has the president of the teacher union vowing to block the re-election of the mayor.[4] This type of resistance is not limited to the massive school closures in Chicago, but instead arises nearly every time a school closure is announced. The rhetoric against closures is that they damage communities and harm children by separating them from their friends and teachers. While some teachers are moved to new schools, many others are laid off. Even students and teachers in non-closed schools can be disrupted by the sudden flow of new students into their schools and classrooms. While nearly everyone is concerned with the potential consequences of school closures, empirical research on their effects is remarkably sparse. In this paper, I expand that literature by estimating the effects of high school closures on both achievement and educational attainment of affected students.

School closures can occur for a variety of interrelated reasons. Most closures are the result of some combination of budget deficits, poor academic performance, and under-utilization (under-enrollment). In traditional districts, fiscal stress often leads to school closures in order to help balance the district budget. This is especially true in

[3] http://www.nytimes.com/2013/05/23/education/despite-protests-chicago-closing-schools.html?_r=0 and http://www.nytimes.com/2013/03/08/education/philadelphia-officials-vote-to-close-23-schools.html

[4] http://articles.chicagotribune.com/2013-05-23/news/chi-chicago-school-closings-20130522_1_chicago-teachers-union-byrd-bennett-one-high-school-program

districts where many schools are under-utilized based on economies of scale. At the same time it is difficult to offer specialized services and classes in an under-utilized school because there are often not enough students to justify the high fixed costs. By closing schools, districts can redistribute the savings to other schools resulting in a more efficient school district.

Even without fiscal or enrollment problems, districts may choose to close consistently poor performing schools. This is especially true in non-traditional districts (such as charter or portfolio districts), which rely on market forces to improve school quality. If certain schools are not meeting academic standards, then policymakers may believe students are better off if the schools are closed and students attend more effective schools.[5] At the same time, the competitive pressure and threat of school closings can potentially motivate schools to keep their performance at or above the required level. As many researchers and policymakers advocate competition as a way to improve school quality (Hoxby, 2003; Friedman 1962), closings are likely to become more prominent. This "creative destruction", which is relatively new to the education sector, works to improve the overall school quality by closing unpopular or poor performing schools to make way for more innovative ones. Thus, it is important to fully understand the effects of these closings, as it they are a key part of the general equilibrium effects of school competition.

There are many potential effects that closing a school could have on students. For example, the closure itself can act as a disruption to a student's learning environment. After a closure, students are separated from many of their peers and teachers (Kirshner, et

[5] There are, of course, other options such as replacing the administration. There also can be discrepancies between what parents, teachers, and administrators deem important.

al., 2009). They will have to adjust to the rules, requirements, and curriculum of their new school. Many students will likely have to travel further to school, which may separate them from neighborhood ties and make it more difficult to get to and from school each day. At the same time, new teachers and classmates will have to adjust to the sudden flow of new students in the classroom, which may lead to an overall lower level of learning (Hanushek, Kain, and Rivkin, 2004; Brummett 2012).

On the other hand, school quality should theoretically increase following closures. If a student's previous school was closed due to poor performance then they should be placed in a school that is better than the one they were attending previously. If a school is closed for under-utilization, then the redistribution of funds and the movement to a more efficient school should likewise improve outcomes. To the extent that school quality and expenditures affect student performance, these changes will positively affect students.[6]

Previous research has shown that all of these theories are probably valid. Most studies find an immediate post-closure drop in achievement followed by a steady increase, sometimes exceeding pre-closure achievement levels and trajectories.[7] This result suggests that any negative effects are temporary and, in many cases, students are better off in the long run. However, students who face closures late in their academic careers have less time to reap the long-term benefits and the short-term negative shocks are more important. As a result, high school closures may be much more likely to cause harm than elementary or middle school closures.

[6] There is a lot of debate in the literature on whether expenditures actually matter (see Burtless, 1996). If it does not affect achievement, then there may be less reason to believe that this is the reallocation of money in the district will be a mechanism for improving performance.

[7] Brummett (2012); De la Torre and Gwynne (2009); and Sacerdote (2012) all find some form of a sudden downward shock followed by a return towards pre-closure levels of achievement.

To my knowledge, this paper is the first to focus on the effect of closing several high schools. I estimate the effect of 33 high school closures on achievement (GPA, attendance, test scores, and discipline) and educational attainment (high school graduation and college attendance). I utilize student-level microdata that cover a seven-year period including five different freshmen cohorts in the Milwaukee Public School (MPS) district. Using difference-in-differences and event study estimations strategies I am able to compare achievement of students before and after school closures to students who did not experience closures over the same time horizon. This paper is also one of the few papers able to examine the impact of closings on post-high school outcomes. Using data matching high school students to their college enrollment, I compare the educational attainment of students who experienced school closures to those who did not, controlling for robust demographic and pre-closure achievement variables.

I find that, after closure, students' GPA and attendance are negatively affected in the short term (1-2 years after closure) declining by approximately 10% and 4% respectively. Standardized test scores are not significantly affected, but this is due, at least partly, to lower statistical power for that part of the analysis. The negative effects on GPA and attendance fade over time, but do not quite reach their pre-closure levels three years after the closure, which, for many students is past the point they would be enrolled in high school. Importantly, students who experience a closure while in high school are less likely to graduate high school and less likely to attend college. These effects are large showing a 6% to 10% reduction in high school graduation and a 3% to 5% reduction in college attendance. The results are robust to weighting by the probability of attrition and are consistent whether the student attends a higher quality school after

closure or not. The event study analysis also reveals that these effects are not driven by endogenous trends in the achievement prior to the closure itself. I find some evidence that test scores of students in recipient schools are negatively affected, but that GPA, attendance, and disciplinary incidents are not.

These results have important implications for policymakers. An often-used justification for the closure of schools is the long-term benefits they can create for future students. However, especially at the high school level, these benefits may never arise for current students. This may be judged a worthwhile sacrifice, but the costs appear non-trivial. It is worth noting that these effects are only measured for students who are displaced by the closure. Cohorts of students who enter high school after the closure schools may potentially be better off, but those effects are outside the scope of this study.

The remainder of the paper is organized as follows: I first review the relevant literature. Then, in section 3, I describe the Milwaukee Public School district. Section 4 describes the data while section 5 describes the estimation strategy. Section 6 examines the results of the estimation followed by robustness check in section 7 and conclusion in section 8.

2. Previous Literature

Even though school closings are now common, the literature examining their effects is still relatively sparse. Qualitative research has shown that students feel more disconnected from their schools, teachers, friends, and community following closures (Kirshner et al., 2009; Lipman and Person, 2007; Steiner, 2009). How those changes affect student performance is less clear. De la Torre and Gwynne (2009) and Brummet

(2012) find transitory negative effects on standardized test scores that begin before the closures take place. The pre-closure dip may arise for several reasons. The announcement of the closure may lead to the best students and teachers leaving before the closure occurs, negatively affecting the remaining students. It also may be the result of a so-called "Ashenfelter's Dip" in which the dip in test scores is, at least partially, responsible for the closure (Ashenfelter and Card 1985). While, Engberg et al. (2012) find transitory negative effects on attendance, they estimate persistent negative effects of on test scores up to three years after closure. They find that these effects can be partially limited by moving students to higher quality schools after closure. With the exception of the Kirshner et al. qualitative study, these papers all estimate the effect of elementary school closures. This leaves the effect of high school closures a, thus far, relatively unexplored area of research.

A related paper by Sacerdote (2010) looks at school closures and relocations in Louisiana due to Hurricane's Katrina and Rita. Like many of the other school closure studies, he finds that students experience a strong negative shock immediately following closure, but that effect is eliminated after a few years. He also estimates the effect that the relocation had on college attendance and finds that New Orleans evacuees had a slightly lower probability of attending college, but non-New Orleans evacuees had slightly higher probabilities. One limitation of this study is that it is not possible to separate out the effect of the school closure from the direct effects of the storm. This leaves the effect of school closures on educational attainment a, thus far, unexplored area of research.

Aside from the direct effects on dislocated students, many researchers have been interested in the spillover effects on students in receiving schools. Engberg et al. (2012) find negative but insignificant spillover effects while Brummet (2012) finds significant negative effects that fade over time. Using displacement due to Hurricane's Katrina and Rita, Imberman et al. (2012) find no average effect on peers, but some evidence that attendance and discipline were affected at the secondary school level.

A related literature examines the impact of general student mobility. This literature is similar because the movement to new schools can still cause many of the same disruption effects for students and their peers. However, they are quite different in the sense that these moves are more likely to be planned and desired by the family. At the same time, these moves will not be accompanied by the simultaneous movement of several of the students' classmates. Nevertheless, the research here can give some insights into what to expect from school closings.

Loeb and Valant (2011) examine student mobility in the same district that is studied in this paper (Milwaukee Public Schools). In their ongoing work they find that mobile students have about a 0.05 to 0.10 standard deviation decrease in test scores. This is similar to results that other authors have found, suggesting that mobility can negatively affect student outcomes, especially in the short-run (Hanushek, et al., 2004; Xu, et al., 2009; Ozek, 2009).

3. Milwaukee School Closings

The Milwaukee Public School (MPS) district is the largest public school district in Wisconsin and among the 40 largest school districts in the nation. Like many other

large urban school districts, MPS is largely a low income (75% free/reduced price lunch), minority (approximately 60% African-American) district. Student academic performance is relatively poor; with standardized test scores well below the national average and four-year graduation rates slightly above 60 percent. Of those graduates only about half continue on to college.

Milwaukee has a long history of offering many different schooling options for parents. In 1990, the city instituted the Milwaukee Parental Choice Program, the nations first voucher program. It remains one of largest voucher programs in the country, providing vouchers for low-income students to enroll in eligible Milwaukee private schools. Milwaukee also has considerable choice within the public school sector. They offer district-wide open enrollment, which means that all parents can choose almost any school in the district to attend (Eadie et al., 2013).[8] The district is also home to many charter schools, which enroll 22% of all MPS students (National Alliance for Public Charter Schools, 2012). These charter schools are overseen by one of three entities: MPS, the University of Wisconsin-Milwaukee, or the city of Milwaukee. Perhaps due to these many options, Milwaukee students tend to be quite mobile, with nearly 40% of students moving two times or more between the 2006-07 and 2010-11 school years (Eadie et al., 2013).

Milwaukee, like Chicago, Philadelphia, and other large urban districts, has experienced large declines in public school enrollment in recent years. Total enrollment in MPS has decreased every year for the last 10 years leading to a nearly 20% decline

[8] While students can choose almost any school, they are not guaranteed enrollment in any school. Attendance zones still exist, allowing students a guaranteed seat in their zoned schools. In situations of over enrollment, priority is given on a variety of criteria and a lottery system is used for the remainder of students. Schools must also provide transportation to students.

over the last decade. Part of this decline is due to changing demographics in Milwaukee leading to fewer school-aged children. Also, the large degree of school choice in Milwaukee has more students choosing private schools and non-MPS charter schools.

With such a dramatic drop in students, MPS has been forced to close nearly 80 schools over the past decade.[9] Importantly, approximately 40 of these closures affected high school students, requiring them to change schools after their freshman year but before graduation. In order to decide which schools to close, MPS considers several important factors such as enrollment, academic performance, and other factors relating to building maintenance and costs. Around December of each year, these schools are announced to the general public, allowing board members, parents, and students a chance to make their case against closure before the final decisions are made in March. Ultimately, this means that parents and students would not know for sure which schools would be closing when they make their open enrollment choices the previous year.

School closings in districts of choice, like MPS, could potentially have very different effects than those in traditional districts. In a traditional district, students are often required to attend their assigned school based on their home address. If a parent is unhappy with their school they have few other options—either pay for a private school or move to another catchment zone, both of which can be costly. When schools are closed in these districts, students are usually re-assigned to other schools nearby.

In an open enrollment district, like MPS, effects of school closure may be different. In the simplest case, with perfect information about schools and without capacity constraints, every student will be attending their optimal school (the one that maximizes utility subject to travel costs). A school closure in this scenario will then

[9] See Appendix Table 1 for a tally of closed schools by year.

necessarily decrease the total utility of families attending the closed school. They will no longer be able to attend their first choice school (since it no longer exists) and instead choose to attend their second best school. This would not be the case in a traditional school district where some parents are "stuck" in a school that is not their top choice. Closing schools in the traditional case could move students to a school they value more than their current school. Even without these simple assumptions, it is reasonable to believe that in open enrollment districts, school closures are more likely to result in students moving to a school they rank lower. On the other hand the change in utility could be smaller in an open enrollment district since (with simplifying assumptions) families would still be able to attend their second best option, which may give a similar level of utility as their first choice.

At the same time, open enrollment districts tend to have higher voluntary mobility.[10] This means there will be more students changing schools and more teachers and students will have new students in their classes. If one of the main mechanisms of school closures is the "disruption" effect, then students in choice districts are potentially less affected by closures than students in traditional districts. Ultimately, it is unclear if students in MPS or other choice districts will be more or less affected by school closures, but it is important to note that the partial equilibrium effects in a competitive market may not generalize to traditional school districts.

4. Data

[10] Eadie et al. (2013) find that students in MPS have the highest rates of mobility of all districts in Wisconsin.

The data for this project, provided mainly by the Milwaukee Public School district, include detailed microlevel administrative student observations that track students as long as they are enrolled in MPS.[11] I utilize data for all MPS high school students (those in grades 9-12) from the 2008-09 to the 2012-13 academic years. The student data also contain their complete MPS academic history, though I only utilize back to the 8th grade record since missing data in prior years would further limit the number of students. I use these data to identify five cohorts of first time 9th graders—those that are first time freshman in the 2005-06 to the 2009-10 academic years. This allows me to observe all five cohorts from their freshman year through their senior year if they are not held back a grade and do not dropout.[12]

The MPS data contain demographic variables such as student birthdate, gender, race, free/reduced price lunch status, English language learner status, and disability information. Academic outcome variables come from a variety of sources. Grade point average (GPA) is calculated using student transcripts. It is calculated as the total grade points earned divided by the number of grade point eligible units taken each year.[13] Attendance percent is calculated as the total number of actual school days attended divided by the total possible number of attendance days. Discipline records are used to create an annual count of discipline incidents and an annual number of suspensions received.[14]

[11] This includes all public schools (including charter schools) run by MPS. It excludes charter schools run by the city of Milwaukee and the University of Wisconsin-Milwaukee. It also excludes any of the private schools including those that participate in the voucher program (Milwaukee Parental Choice Program).
[12] The 2005-06 to 2007-08 cohorts are only observed for those students who attend an MPS school in 2008-09.
[13] Standard grade point values are used where an A yields 4 points, a B 3 points, etc.
[14] The raw discipline incident data are coded into many different categories. Common examples include: "chronic disruption", "refusal to work". "personal threat", "verbal abuse/harassment", "assault" and "fighting".

Also available are the Wisconsin Knowledge Concepts Examination (WKCE) standardized test scores. These are state mandated standardized tests given each fall to all students in grades 3-8 and 10.[15] For this paper I will only be utilizing the 8th and 10th grade test scores in math and reading, restricting the power of these estimates and time frame of the analysis relative to the other outcome variables. Scores are standardized by year, grade, and subject to have mean 0 and standard deviation 1.

Education attainment data are collected by MPS from the National Student Clearinghouse (NSC). The NSC data include information on high school graduation and college attendance.[16] The data cover approximately 91% of all US postsecondary students (Dynarski et al., 2013). While it is not possible to differentiate students who did not attend college from those who attend schools outside the scope of the NSC data, the cases of the latter are rare in Milwaukee (Carl et al., 2009). The college attendance data contain the name of the college attended, whether it is a two-year or four-year college, whether it is a public or private, and whether the college was in-state or out of state.[17] These data are only available for students who received a diploma while enrolled in MPS. Due to the fact that these are recent high school graduates I focus on information about the first college attended after high school.

I use these data to create several measures of educational attainment. The first is high school graduation, a dichotomous variable equal to one if the student received a diploma. On-time graduation is an indicator if the student graduated high school within four years of their first-time freshman enrollment. College attendance is an indicator

[15] Some students may not take the exam if they are absent on test days or have certain learning disabilities.
[16] The data do not differentiate between true high school diplomas and other nontraditional diplomas such as GEDs.
[17] College degree receipt data are also available, but not enough time has elapsed from high school graduation for this to be useful information.

equal to one if the student attends any type of college after high school. In some estimations that is split between two-year and four-year colleges.

Data on school closings were also made available by MPS. These data identify the year of school closure for all schools within MPS from 2001-02 to the present. I focus on true school closings rather than building moves or school mergers.[18] These are schools which cease to exist before all students have had the chance to graduate and do not combine with other schools in the district. Finally, I also collect school level data from the Wisconsin Department of Public Instruction (DPI) on yearly school enrollment, attendance percent, graduation rates, and 10th grade WKCE proficiency.

Summary statistics of all MPS variables are presented in Table 1.[19] This includes data for 26,315 students across 89 different schools. Approximately 60% of students are African-American with another 19% Hispanic and only 11% white. The average student receives a yearly GPA of 1.9 (out of 4) and attends school 80% of school days. Approximately 61% of ninth graders and 89% of 12th graders graduate from high school by the end of the 2012-13 school year. Nearly 58% of those students go on to attend some type of college (36% 2-year and 63% 4-year colleges).

5. Estimation Strategy

There are two types of outcomes that I examine in this paper each requiring a different identification strategy. The "achievement" outcomes (GPA, attendance, discipline, and test scores) are measured at multiple points in time, allowing me to utilize

[18] There were only two high schools that merged with each other during my sample period and another two that merged with a high school. All results are robust to separately controlling for merger effects.
[19] The sample excludes students with odd grade transitions such as moving backwards a grade and jumping several grades in one year.

the panel structure of the data to account for differences both within and across individuals over time. The "attainment" outcomes (high school graduation and college attendance) are only measured once, so estimation is based off of differences across measurably comparable students. Below I separately describe each estimation strategy in detail.

5.1. Estimation of Achievement Effects

School closings in Milwaukee are not random. The district specifically takes into consideration the academic performance of the school when making their closure decisions. Therefore, simple comparisons of outcomes across students will be biased towards finding negative impacts of school closures. Table 2 demonstrates this phenomenon by comparing students with and without closures *before* the closures occur (i.e. in the 8^{th} and 9^{th} grade). As is clear in the table, students who will experience a closure are already performing worse on almost every academic measure compared to those who will never experience a closure. They are also more socioeconomically disadvantaged (more likely to receive free/reduced price lunch) and more likely to be diagnosed with some type of disability.

To control for these differences I utilize a generalized difference-in-differences estimation strategy. This strategy compares the difference between student achievement before and after a closure to the difference in achievement across the same time interval for the comparable students who did not face a closure. By looking within student difference, I effectively eliminate the bias that would otherwise be caused by these pre-closure differences. To implement this strategy one could estimate the following model:

$$Y_{ist} = \beta_1 AfterClose_{it} + \theta_i + \delta_{gt} + \varepsilon_{ist} \quad (1)$$

Y_{ist} is the outcome of interest (GPA, attendance, discipline, or test score) for student *i* in school *s* during academic year *t*. $AfterClose_{it}$ is an indicator variable equal to 1 for student *i* if *t* is an academic year after she has been relocated due to a school closure and 0 otherwise.[20] To be counted as a closure, the school must close before the student reaches the highest grade in that particular school. Similarly, the year after closure must not be the students' first time in the lowest grade of the receiving schools. This is done in an attempt to ensure that the reason for the student switching schools is the school closure and not a move that would have occurred otherwise.[21]

Student fixed effects are designated θ_i and control for any observed and unobserved student characteristics that are constant over time, such as race, gender, ability, and pre-closure achievement. The ability to control for these pre-closure outcomes is vital to obtaining causal estimates because it will control for the baseline imbalances shown in Table 2. Finally, δ_{gt} are grade-by-year fixed effects that control for any within grade and year constant effects that may also affect achievement. This controls for any district wide changes in policies from year to year that may affect these outcomes, such as changes in attendance policies or changes in standardized tests.

In addition to direct effects on displaced students, there may be spillover effects on students in receiving schools. To examine this, I include variables that measure the fraction of students in school *s* and year *t* that are new to the school and have come from a school that was closed the prior summer. The percent of students from closure schools

[20] If the student faces more than one closure this variable is based upon their first closure. A similar rule is used for voluntary movers.

[21] All results are robust to simply ignoring the grade structures of the school and allowing any student who was in a school the year before it closed to be treated.

is interacted with indicators for whether or not the student themselves are from a closure school. This helps separate out the differential effect this might have on students coming from closure schools themselves versus those who have been a member of the school previously. The interaction with non-closure students will identify the possible spillover effects of the closures on non-closure students. Controlling for spillover effects yields the following equation:

$$Y_{ist} = \beta_1 AfterClose_{it} + \beta_2 FracCloseStud_{st} * 1[JustClose_{ist} = 1] + \beta_3 FracCloseStud_{st} * 1[JustClose_{ist} = 0] + \theta_i + \delta_{gt} + \varepsilon_{ist} \quad (2)$$

Finally, I include several other variables that vary by student and over time. I include an indicator variable that signals if the student has recently moved voluntarily (i.e. not due to a closure). While this variable is endogenous and results should be interpreted with caution, it provides a useful context and comparison for the effects of closure caused moves. I also include a measure of the fraction of students in each school who are new to the school as a control for the amount of turnover the faculty and students experience. Finally, I include several time-varying student level characteristic: free-reduced price lunch status, disability status, and English language learner status. This leads to my preferred estimation equation:

$$Y_{ist} = \beta_1 AfterClose_{it} + \beta_2 FracCloseStud_{st} * 1[JustClose_{ist} = 1] + \beta_3 FracCloseStud_{st} * 1[JustClose_{ist} = 0] + \beta_4 AfterVolMove_{it} + \beta_5 FracNewStud_{st} + \beta_6 X_{ist} + \theta_i + \delta_{gt} + \varepsilon_{ist} \quad (3)$$

5.2 Dynamic Estimation of Achievement Effects

While the difference-in-differences strategy can control for many unobservable differences, it does not do a good job of controlling for pre-existing trends. That is, outcomes may look different on average before versus after a closure simply due to trends in the outcome variable over time. This may be especially true if schools close because student outcomes are declining over time. To account for this possibility I adapt equation (3) into an event study and estimate the following equation:

$$Y_{ist} = \sum_{j=-3}^{2} \lambda_j Close_{itj} + \beta_2 FracCloseStud_{st} * 1[JustClose_{ist} = 1] + \beta_3 FracCloseStud_{st} * 1[JustClose_{ist}0] + \beta_4 AfterVolMove_{it} + \beta_5 FracNewStud + \beta_6 X_{ist} + \theta_i + \delta_{gt} + \varepsilon_{ist} \quad (4)$$

In this equation $Close_{itj}$ is an indicator variable equal to 1 if student *i* in year *t* experiences a closing *j* years from *t*.[22] Student observations more than 3 year prior to closure or students that do not experience a closure are categorized at *j*=-3. Students more than 3 years past their school closure are categorized as *j*=2.[23] The λ_j coefficients will allow me to identify the effect of closure up to three years before and three years after the closing (with j=0 being the year immediately after closing).

Another benefit of the event study analysis is that it allows for the examination of effects at different points in time. As Brummett (2012) and others have pointed out, effects may "dip" the year before closure as the announcement itself may affect student

[22] *j*=0 will refer to the year immediately after the school closes and therefore the first year the student is relocated.

[23] Due to the fact that high school is only 4 years long (without grade repetition) school closures between different grades will identify different λ_j's. For example a school closure between 9th and 10th grade can help identify the effect of closures two years after they happen but would not be able to help with the effect 2 or 3 years before closures. Later, I show results that separate the effects based on student grade at time of closure.

and teacher performance. The effects of the closure may also fade over time as students adjust to their new school.

Finally, to account for the possibility of standard errors being correlated within schools, all standard errors are multi-way clustered at both the ninth grade school and the current-year school. This is true of standard errors in both the difference-in-differences estimation as well as the event study analysis.

5.3 Estimation of Attainment Effects

The estimation of attainment effects requires a different strategy than the one used on the achievement variables. Since the attainment variables are only observed once, it is not possible to include student fixed effects and utilize a difference-in-differences strategy. Instead I estimate an OLS model which controls for pre-closure demographics as well as 8th and 9th grade (pre-closure) achievement and 9th grade school characteristics.

$$Y_i = \beta_1 Close_i + \beta_2 X_i + 8thGrSchoolFE_i + 9thGrSchoolChar_i + Cohort_i + \varepsilon_i \quad (5)$$

In this equation, Y_i are various measures of educational attainment. Measuring attainment is complicated by the fact that it is not possible to distinguish dropouts from movement to non-district schools. Also, due to the fact that many of the cohorts are only observed for four or five years after they start ninth grade, delays in graduation may appear as non-graduation. Due to these issues, I focus on three measures of high school graduation: graduation, "on-time" graduation,[24] and the graduation for students who are observed in 12th grade. The on-time graduation variable makes it so all cohorts have an equal opportunity to reach this outcome as all are observed for at least 4 years. The 12th

[24] "On-time" graduation is defined as any student who graduates within 4 years of their first-time freshman year.

grade graduation rate is likely to get at a purer measure of graduation since a student is less likely to move out of district given that they are observed in district in 12th grade. College level attainment variables are analyzed in two ways. The first is to only estimate the college level outcomes for high school graduates since these are the only students for whom I observe these outcomes. The second assumes that all non-graduates do not go on to attend any college. While this is likely too strict an assumption it is not unreasonable to assume that many of these students will not go on to college.

The variable $Close_i$ is an indicator variable equal to 1 if the student is not in 12th grade and in a closure school immediately prior to closure. X_i contains a large amount of individual demographics and pre-closure achievement measures. This includes race and gender indicators as well as indicators for free/reduced price lunch, English language learner status, and disability status. It also includes controls for 8th and 9th grade achievement, which are strong predictors of attainment. This focuses the comparison on students who are expected to attain similar levels of schooling absent any school closures.

$8thGrSchoolFE_i$ are 8th grade school fixed effects while $9thGrSchoolChar_i$ are previous-cohort school level characteristics of each student's 9th grade school.[25] Taken together, effects are identified from the difference in outcomes for students in closed schools with those who attended the same 8th grade school as well as academically and demographically similar 9th grade schools. This will help control for unobserved factors related to school choice as well as the average quality of the school attended. Finally, $Cohort_i$ is a set of ninth grade cohort fixed effects. These serve a dual purpose of

[25] The lagged 9th grade school characteristics include average GPA, attendance, discipline incidents, 10th grade math and reading WKCE scores as well as the fraction of students receiving free/reduced price lunch and fraction minority. They are lagged to represent the characteristics the families would observe before attending the school.

controlling for changes over time as well as controlling for the fact that later cohorts have had less time to attend college. All standard errors in the attainment regressions are clustered at the 9th grade school level.

6. Results

Before examining the estimated effects, it is worth examining descriptive statistics on the types of schools being closed and the types of schools students attend after closure. The first column in Table 3 contains the school characteristics of the closed schools the year before closure.[26] The second column contains school characteristics of the receiving schools where the characteristics have been lagged so that they do not take into account the relocated students themselves. Column 3, provides the overall sample averages for students who do not experience a closure.

As expected, recipient schools have much higher enrollments than closed schools—nearly twice as much. Recipient schools also perform better academically. They have higher graduation rates, attendance rates, and rates of performance considered "proficient" or "advanced" on the WKCE. They also have higher average GPA and fewer disciplinary incidents. This suggests that on average, students are attending what many would consider to be "better schools" after closure. These statistics also confirm that MPS is mostly targeting low performing and under enrolled schools for closure.

While recipient schools appear better than the closed schools, they still perform below district average on almost all measures of academic success. So, while students are moving to somewhat better schools after a closure, they are still attending relatively low quality schools. Even choice does not appear to guarantee enrollment in the highest

[26] Estimated means are calculated at the student level and are therefore weighted by school size.

quality schools. One reason is that students and parents may care about school characteristics that are not captured in these measures (Harris, Larsen, Zimmerman, 2014). Another reason may be that it is difficult for students from closure schools to get into the top schools in the district. Some schools may have selective admission processes while others may be oversubscribed and, therefore, without an open seat to offer to closure students. Whatever the reason may be, many closure students still attend below average schools even after they have relocated.

6.1 Achievement Results: Difference-in-differences

In order to estimate the average effects of experiencing a closure, I estimate equation 1 and present results in Table 4.[27] The first column estimates effects on yearly GPA. Following a school closure students have a GPA that is 0.17 grade points lower (on a 4.0 scale) than they would absent a closure. Relative to the average GPA of 1.9 this is approximately an 8.8% decrease in their GPA. On the other hand, students who voluntarily switch schools have a GPA that is 0.09 grade points *higher* than they would otherwise.

There are several possible reasons for this pattern in GPA. One is a disruption effect, in which the closure has disrupted the students' learning by forcing them to adjust to new classmates, teachers, and rules. While this disruption is not seen after a voluntary move, voluntary moves are much more likely reflect problems students are having in their original school and therefore more likely to be beneficial to the student. Another

[27] These estimates are for the full sample of students. Estimates limited only to those students for which the student outcomes are not measured retroactively are presented in Appendix Table 2. Estimates limited only to those students that experience a closure are presented in Appendix Table 3. Results in both of these tables are very similar to the main effects measured in Table 4.

possible reason for the post-closure decline in GPA is that the new school may grade more stringently than the closed school, which would cause a decline in GPA without any effect on the students' effort or performance. To account for this possibility, I run the same regression but control for how easily each school grades their students.[28] The results are a similar and statistically significant effect of -0.15, suggesting that the effect is not due to difference in grading rigor.[29] It is also possible that the course composition changes after closure, and the effect is due to students taking more difficult courses after closure. However, limiting the GPA to "core" courses yields nearly identical effects.[30] No matter the mechanism, the key for the students is that they will have a GPA that is nearly 9% lower than they would without the closure. This means it will be more difficult for them to meet minimum graduation and scholarship requirements, as well as to meet sports eligibility and grade advancement criteria.

Attendance is also negatively affected by both closure related moves and voluntary moves, though the negative effect is larger for students who were relocated due to closures. Experiencing a closure results in a 3.2 percentage point decrease in attendance. Relative to the MPS mandated minimum of 180 school days the closure results in approximately an extra 6 days of school missed. This decrease could be caused by many factors. Travel costs to the new school may be higher than they were previously, which may mean that there are some days where the student cannot make it to

[28] Only including the GPA at the average test score may miss how schools grade students at the tails of the distribution. To account for this I include the school average GPA at several levels of WKCE math scores. Specifically I include the school average GPA for students between the average test score and 1 standard deviation above average, between 1 and 2 standard deviations above the average and greater than 2 standard deviations above the mean. I also include the average GPA between 0 and 1 standard deviation below the mean, between 1 and 2 standard deviations below the mean, and lower than 2 standard deviations below the mean.

[29] Results not shown in tables but available upon request.

[30] "Core" courses are defined as Mathematics, English, Science, and Social Studies. Results are available upon request.

school. Students might skip school more often if they are less satisfied with their new school. If their GPA drops (as seen earlier) students may become discouraged and skip more days of school as well. These missed school days mean that students are missing valuable instruction time, which could affect their ability to advance in grade and eventually graduate.

There are several reasons to think school closures and movement may affect disciplinary incidents. For one, school level peer groups have been found to affect delinquent behavior (Gaviria and Raphael, 2001). By forcing students to change schools, students are placed in a peer group with a different (often lower) propensity for having behavioral issues. It is also possible that some students may have earned an unfavorable reputation with their teachers and administration in their original school, resulting in more frequently reported incidents. Movement to a new school could then provide a "fresh start" for these students. At the same time, the disruption and separation of students from their routine may affect psychological well-being and cause behavioral issues (Rumberger and Larson, 1998). Frustration with their slipping grades and difficulty learning new rules may also lead to an increase in incidents after the closure.

I find no significant effect of closures on student discipline infractions. This could be because these policies do not affect disciplinary incidents, or because the different mechanisms counteract each other resulting in a no net effect. However, the effects for voluntary movers are strong and negative. Voluntary movers have an average of 1.6 fewer incidents and 0.8 fewer suspensions. One reason for the difference in effects may be that voluntary movers are less likely to be frustrated by the move because they see gains in GPA and potentially welcome the change in schools. This would be

consistent with the effects seen on student GPA. At the same time they still benefit from the "fresh start" of moving to a new school.

The analysis of WKCE test scores must be slightly modified since these tests are only taken in 8th and 10th grade. The analysis only includes those students that experience a closure before the 10th grade. Results from are presented in Table 5 and include results for the WKCE math and reading tests as well as for the same four outcomes examined in the full sample in Table 4.

Overall, with fewer students there is less power to identify significant effects across almost all outcomes. Effects on the original four achievement variables are mostly consistent with their analysis on the full sample. The coefficient on GPA is about half as large as the full sample, which may suggest that 9th grade closures are less harmful to GPA. The magnitude of closure effects on math test scores is consistent with the effects seen in other papers, while reading test scores suggest a positive effect of closures. However, like most of the other variables these effects are not significant. It is also important to note that the WKCE exams are given in the fall, so there is little time for changes in instruction at the new school to affect these students' performances.

Another key aspect of closures is that they bring a new population of students to non-closed schools. For all outcomes, the fraction of new, non-closure students in a school and year is beneficially related to achievement. There are several potential explanations for this. Having many new students may affect how teachers grade their students, potentially grading easier to compensate for the many new students. New students also can shake up social circles, which might affect discipline. Many new students also could be a proxy for a change in school quality that is attracting new

students to select the school. While the magnitude of these effects appears large, the reported estimate is the effect of moving from 0 new students to 100% new students—the mean and standard deviation of this variable are 0.42 and 0.16 respectively. For example, increasing the fraction of new students by 10 percentage points will increase a student's GPA by about 0.07 GPA points (about 4% of the mean GPA).

In Table 3, the fraction of closure students at the school has mostly beneficial or insignificant effects on both closure and non-closure students. Like the fraction of new students, these effects appear large, but when compared with the mean and standard deviation of 0.02 and 0.05 respectively, the effects are more reasonable. The beneficial spillover effects are contrary to previous studies that find new students tend to disrupt the learning environment, negatively affecting the original students (Brummett, 2012; Loeb and Valant, 2012). One possible reason for this inconsistency is the difference in outcomes being examined. New students have been shown to negatively affect standardized test scores, but it is unclear how they should affect the additional outcomes being examined here such as GPA. The results in Table 5 suggest that the difference in results may indeed be due to the outcomes being examined. Here, standardized test scores are universally negatively affected by all types of new students, but the other outcomes suggest mostly beneficial effects of new students.

6.2 Dynamic Achievement Effects

In order to observe how the effects of school closures change over time, I rely on an event study analysis and present these results in Table 6 and Figures 1A-1D. It is not possible to explore the effects of the WKCE exams in this way due to the lack of annual

test score data in high school, so the results are limited to the initial four outcomes. Following convention, the interaction between school closure and the period immediately before the closure is the omitted reference group.

In the years prior to closure, GPA was on a very slight upward trend before dropping suddenly the year after the closure. In the second year after closure, GPA continues to decrease slightly. By the third year post-closure the estimates are returning towards their pre-closure levels. The point estimates are still negative and sizeable, but no longer significantly different from zero. This is partially due to an increase in the point estimate and partially due to an increase in the standard errors, as fewer students appear in the data this long after a closure. While it is encouraging to see the estimates returning to zero, older students will not be enrolled in high school long enough to reach that point. Even for the younger students their cumulative GPA, which will matter for graduation and scholarships, will still suffer.

Effects on attendance show a slight downward dip the year prior to closure. This could be in response to the closure announcement, which could be discouraging to students and faculty in the school. Whatever the cause of the small dip, there is a much sharper decrease in attendance immediately after the closure. Like GPA, the effects stay below zero after closure but return much closer to their pre-closure levels three years after the closure.

While the event study analysis provides strong evidence of a causal effect of school closure on GPA and attendance, it does not yield any evidence that closures affect disciplinary incidents. In Figures 1C and 1D the effects are mostly flat both pre- and

post-closure with no noticeable increase or decreases immediately after the student moves.

One concern with these figures is that they are created using an unbalanced panel This is true for two main reasons: (1) the grade at which a student experiences a closure necessarily dictates how many pre- and post-closure periods they see, and (2) some students dropout or finish high school before other students. This leads to some concern that effects seen in Figures 1A-1D are driven by sample composition rather than a true closure effect. To address the latter concern, I limit the sample to only those students who exist in the data for the four consecutive years after school entry and advance a grade in each subsequent year. The tradeoff of this approach is that the sample is comprised of a unique type of student that may not reflect the population average.

Results of this exercise are presented in Figures 2A-2D and appear consistent with the effects measured in Figure 1.[31] Figure 2A shows a more pronounced upward trend for GPA pre-closure and a slightly larger drop immediately after closure. The estimated drop in attendance in Figure 2B is slightly smaller than the unbalanced panel estimate, but still statistically significant. Effects on both measures of discipline infractions are still flat and insignificant.

Finally, to address the issue of the timing of the closure, Figures 3A-3D display estimates of closure on the balanced panel separately by grade of closure.[32] The effect on GPA is consistent across all closure grades, showing a sharp drop immediately following a closure. The same is true of the effects on attendance with the possible exception of 11th grade closures that show a negative pre-closure trend. It is worth noting that the

[31] Appendix Table 4 presents the estimates in a table.
[32] Appendix Table 5 presents the estimates in a table.

decline after closure is much sharper than the pre-closure trend. Effects on discipline incidents vary by grade with 9th grade closure actually increasing disciplinary issues. However, effects of closures in 10th and 11th grade are relatively flat.

Overall, these results provide strong evidence that the effects of closure are not due to differences in trends across closure and non-closure students. The effects on GPA and attendance are well defined and significant around the event of the closure. Performance may eventually return to its pre-closure level, but for many students the effect will remain until they exit high school. Because of this, it is possible that these effects can have longer-term outcomes for students including effects on their educational attainment.

6.3 Attainment Effects

Attainment effects are calculated on a variety of outcomes using estimation equation 3. Due to limitations in the data, I estimate high school graduation using three different measures; and report results in Panel A of Table 7. The first is the overall graduation rate as measured by diploma receipt.[33] The OLS results suggest a 9.3% decrease in the graduation rate of students with closures. However, some students may take more than four years to graduate, which may mean that later cohorts in the sample are classified as non-graduates when they were instead only delayed. To avoid this misclassification, I also estimate the effects on "on-time" or four-year graduation and find a nearly identical 9.4% decrease due to closures. Finally, it is not possible to identify what happens to students who leave MPS before graduation. While many likely dropout of school

[33] The data do not differentiate between high school completion diplomas and alternative diplomas such as GED receipt. Therefore any student who receives a diploma is considered a graduate.

altogether, some may move to schools outside of the district (private, non-MPS charter, outside of city, etc.). I therefore estimate the graduation rate of the subset of students who are in MPS until 12th grade as my final specification. Students who are enrolled in MPS in 12th are less likely to change schools out of district and still receive a diploma. Students in this category who do not receive a diploma from MPS probably have not received one at all. The tradeoff of estimating the effect on these students is that they have persisted in school after experiencing a closure and may be a special group of students that are more likely to graduate. Closures decrease the graduation probability of these students by 5.8%. Smaller than the overall rate, but still a sizeable negative effect.

The remaining panels display estimates of college enrollment. College information only exists for students who graduate from MPS. Panel B estimates effects on this sample of students. Like the students persisting to 12th grade, estimates on this sample are for students who are able to experience a closure and still persist. There is no overall effect of college going on this sample of students. However, when examining two and four-year college attendance there is a significant 3.2% decrease in the probability of attending a two-year college and no effect on four-year college attendance. This is probably because students affected by closures have lower academic performance and therefore more likely to be on the margin of attending a two-year college than a four-year college. Four-year college attendance also requires more planning (such as taking the ACT/SAT), which may have been completed prior to some of the closures.

Results in Panel C are for college attendance assuming that all non-graduates do not attend college. While this is likely not true, it is not unreasonable to think that the vast majority of non-graduates (especially those in closure schools which are generally

low performing) do not go on to attend college. When making this assumption there is a significant decrease in total college attendance of 4.8% due to closure. As before, this is mostly due to 2-year college attendance, though there is now an insignificant decrease in 4-year attendance as well.

6.3 Attainment Effects by Grade of Closure

To examine whether effects are different by the grade of closure I separate the closure indicator into three separate indicators depending on the grade at which the closure took place. Ex-ante it is difficult to hypothesis which grades will be most harmful to student achievement. As shown earlier, negative achievement effects tend to persist for at least two years. Thus, closures that happen in ninth grade may lead to the longest duration of "treatment". However, students tend to dropout more often in later grades and perhaps the immediate shock of the closure in these grades is enough to push them out of school entirely.

Estimates of graduation and on-time graduation suggest that 9th grade closures are most harmful for students. Closures at this level mean lower GPA and attendance values at 10th and 11th grade and a much lower cumulative GPA which may make graduation more difficult. While closure effects in 10th or 11th grade are large as well, more students may be on their way to graduation before closure and decide to persist after. Estimates on 12th grade graduation are most negative for closures that occur in 11th grade. One reason for this is that students who have had closures in 9th grade may have already dropped out before 12th grade. Those who have a closure in 11th grade have a sudden

shock in 12th grade and may enroll in their new school only to decide they do not like it and instead drop out.

For college attendance, the effect is strongest for closures between 10th and 11th grade and on 2-year college attendance. There are a few possible reasons for this. First, the 9th grade closure students were more likely to dropout and so the sample of graduates is restricted to students with a higher probability of attending college. Second, 11th grade tends to be the most important for students deciding to go to college. When assuming that all non-graduates will not attend college and estimating on the entire sample, the effects are more similar across grades. This is because some of the students who did not graduate due to a ninth grade closure would have gone to college. Adding them back into the calculation leads to a similar (though slightly smaller) sized effect as 10th grade closures.

Overall, these results suggest that beyond the contemporaneous achievement affects seen during high school, school closures can have long lasting and important effects for students. Decreasing graduation rates and college going can lead students to higher levels of unemployment and lower levels of earnings throughout their lifetimes.[34]

6.5 Effect Heterogeneity

So far, I have only examined average effects across the whole population of closures. However, as previous authors have pointed out, the effects may be different depending on the change in school quality after closure (Engberg et al., 2012; Brummett, 2012). In Milwaukee, this change in quality is likely to be endogenous because of school choice policies. One should be very cautious about any causal impacts of post-closure school

[34] See Card (1999) for a review of this literature.

quality, as differences are potentially driven by this endogeneity. Nevertheless, this exercise will be informative to examine.

I estimate closure effects separately based on the difference in quality of the closed and receiving schools. To be specific, I interact the closure variable with an indicator of "quality" signaling if the student attends a school with a better average combined WKCE math and reading score, and an indicator signaling if the student attends a school with an equal or worse average score.[35]

Table 9 estimates the heterogeneity of achievement and attainment using modified versions of equations 3 & 5. Interestingly, effects on GPA are much worse for students who attend higher quality schools. This may be because the level of difficulty is greater at higher quality schools so it is more difficult for students to maintain their previous GPA. On all other achievement measures, the effects are indistinguishable across post-closure school quality.

The second part of Table 8 investigates the differential effect of post-closure school quality on attainment. High school graduation variables suggest that students are less likely to graduate if they attend a worse quality school after closure than if they attend a better quality school. However, students who graduate are less likely to go to college if they attend a "better" school. This could be that the better quality schools succeed in getting students through schools, but due to the lower GPA they do not have the qualifications necessary to attend college. It is worth noting that statistically I cannot rule out the possibility of equal affects across receiving school quality on all attainment outcomes.

[35] The combined score is the sum of the reading and math scores and then transformed into a z-score.

Overall, there is not strong evidence that effects are significantly different for students who attend better quality schools. This is in contrast to Engberg et al. (2012) who find that attending a better quality school mitigates the negative effects of school closures. There are several potential reasons for this discrepancy. Engberg et al. examine both a different outcome (standardized test scores) and use a different measure of quality (school performance score).[36] It is also likely that Milwaukee has more choice than the district studied in Engberg et al.[37] If so, students are more likely to sort into the best remaining school available to them after closure in Milwaukee. While on observables some schools may look worse than others, students will choose the best fit for them. If this is the case, then it is not surprising that results are similar across post-closure school quality as measured only by the observable test score.

7. Robustness

7.1 Pre-Closure Changes

There is some concern that the timing of the school closures is endogenous. Students could know that a school is closing and leave before the school closure actually takes place. This would yield estimates of closure being based on only those students who did not have the means or knowledge to leave before hand. To examine this, I estimate a modified Equation 5 where the outcome is either an indicator that the student remains in the sample the following year or an indicator if the student is in a new school the following year. I do this separately for students in 9th grade and 10th grade. The key

[36] School performance score utilizes several value added measures of achievement. This metric is used in the district Engberg et al. (2012) examine, but similar report cards were not available in MPS until the 2011-12 school year and are therefore not used in this paper.

[37] The district studied in Engberg et al. (2012) is anonymous and so it is impossible to be certain about the exact extent of choice in that district. However, few districts have more choice than MPS.

covariates are whether or not the student is in a school that closes in two years and an indicator if the school closes the following year.[38]

Estimates are shown in Table 10. In both 9th and 10th grade there is no statistically significant effects on leaving MPS or changing schools when the school is closing in two years. This suggests that students are either not aware that the school will be closing, or not acting on that information. In contrast, if a school is closing at the end of the year, the student is more likely to be out of the district the following year. Of course mechanically a student who stays in the district must be in a new school the following year since the current school no longer exists, so it is not a surprise to see a very large positive affect of attending a different school the year after closure.

7.2 Attrition Weighted Achievement Estimates

As seen in Table 10, students who experience a closure are more likely to leave the sample. This draws some concern about the achievement estimates estimated in Table 4 since this is estimated for the sample of students who remain in the district. It is likely that the attritors are the lowest performing students, which means that the estimates excluding them are underestimates of the true effect. However, to check if this attrition is driving results I follow Sacerdote (2012) and weight the regressions by the probability of attrition based on pre-closure characteristics. These results are shown in Table 11 and are very similar and statistically indistinguishable from the non-weighted estimates in Table 4.

[38] I do not look at 11th or 12th grade because a student in those grades would not necessarily be affected by the actual closure if they remain in their current school.

7.3 Difference-in-Differences Attainment Estimation

The attainment estimates in Table 7 control for many observable characteristics that may affect graduation and college attendance and are correlated with having a closure. However, it is possible that there are still some unobservable factors along this dimension. If that is the case the estimates will be biased. To control for these unobservable factors I utilize a different estimation strategy: school-cohort level difference-in-differences.

Within a school that will eventually close, some students will go through a closure while others will not simply due to the year in which they entered high school. For example if a school closes in 2011-12, the 2009-10 freshman cohort will experience the closure while the 2007-08 freshmen cohort will not. Due to high mobility rates as well as grade retention, cohorts will not perfectly identify those students affected by closures. Some students may switch into and out of closure schools before the closure occurs leading to an incorrect designation. At the same time students staying more than 4 years in a school may experience a closure when they were identified not to. Because of this, the estimates in this method are likely to be imprecise. However, the identification is based only on the year in which a student entered high school, which is primarily driven by year of birth. This should be exogenous to graduation.

To estimate this model I aggregate the data to ninth grade school-by-ninth grade cohort level means. I then create a treatment indicator that is equal to one for cohorts entering a school within 4 years of closure and 0 for everyone else. I include cohort and school fixed effects and (in some specifications) average 8^{th} grade characteristics.

These estimates are available in Table 12. In this specification very few estimates are statistically significant overall. Only the overall and two-year college attendance estimates for high school graduates are significant. However, most of this is due to the relatively poor level of precision and not small point estimates. In fact, most of the estimates are very similar, if not larger, in magnitude than those found in the individual analysis using Equation 3. For example, the point estimate on graduation suggests a decrease in the graduation rate of 7.5 percentage points. Compared to the mean rate of 63.4% this is an 11.8% decrease in graduation, slightly larger than the 9.3% found using the student level comparisons. The difference in precision is likely a combination of the smaller sample size combined with the imprecise measurement of who actually faces a closure.

While almost all estimates of this strategy confirm the estimates in Table 7, there are two notable differences. First, the difference-in-differences estimate on 12^{th} grade graduation is small and positive. Second, the difference-in-differences estimates on four-year college attendance are nearly identical to the two-year college rate, suggesting a more equal affect across these margins. These two discrepancies may suggest further investigation into the effect on these two outcomes before drawing conclusions.

8. Conclusion

School closings are likely to only become more prevalent as districts opt for more school choice and accountability policies continue to target poor performing schools. While other authors have examined the effects of closing elementary and middle schools, there is much less research into closing high schools. In this paper I find that closing high

schools in Milwaukee has mostly detrimental effects for student achievement—decreasing both GPA and attendance percentage. The closings also have attainment effects for the students who experience a closure, decreasing both high school graduation rates by nearly 10% and college enrollment rates by 3-4%. The effects exist even if the student attends a better quality school after closure.

These results are potentially important for policymakers. While studies of elementary and middle school closings often find either positive or insignificant long-run effects of school closings, those students have many years to get back on track. When high schools are closed, the disruption comes at a key point in a student's academic career with little time to recover before graduation and college enrollment. While avoiding high school closures altogether is likely unrealistic, these results highlight the importance of exploring alternative strategies. Several districts institute "phase-out" options where new cohorts are not admitted and remaining cohorts are allowed to work their way through to completion. However, it should be noted that the effects of these types policies have not been thoroughly studied and may have negative effects of their own as teachers and students begin to leave the "sinking ship".

While these results are important, one should use caution before trying to generalize. I only estimate effects for one district. As mentioned earlier MPS is unique for its large amount of choice options including open enrollment schools, charter schools, and a large voucher program. There are several reasons to believe that school closings in this type of district may have different effects on students than closings in traditional districts. More research should be done comparing closures in choice districts and traditional districts. The effects are also limited to the students who actually experienced

a closure. The closures may be particularly helpful for future cohorts of students who perhaps would have attended the closed school had it not closed, but those effects are outside the scope of this paper.

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Table 1: Summary Statistics

	Obs	Mean	Std Dev	Min	Max
Demographics					
Female	97,562	0.497	0.500	0	1
Free/Reduced Lunch	97,562	0.754	0.431	0	1
English Language Learner	97,562	0.066	0.247	0	1
Disabilities	97,562	0.210	0.407	0	1
White	97,562	0.110	0.314	0	1
Black	97,562	0.631	0.483	0	1
Hispanic	97,562	0.187	0.390	0	1
Asian	97,562	0.050	0.219	0	1
Attend Local School	99,215	0.082	0.275	0	1
Academic Outcomes					
GPA	94,462	1.911	1.072	0	4
Attendance	98,696	0.800	0.218	0	1
Discipline Incidents	98,706	2.546	5.165	0	113
Discipline Suspensions	98,706	1.177	2.519	0	40
WKCE Math (10th Grade)	22,246	0.019	0.999	-3.143	5.111
WKCE Read (10th Grade)	22,177	0.013	1.001	-2.936	5.400
Graduation and College					
Graduates (9th Grade)	26,290	0.613	0.487	0	1
On-time Graduates (9th Grade)	26,290	0.563	0.496	0	1
Graduates (12th Grade)	16,173	0.893	0.309	0	1
College Attendance (Graduates)	16,121	0.581	0.493	0	1
2 Year College	16,121	0.211	0.408	0	1
4 Year College	16,121	0.367	0.482	0	1
Mobility and Closures					
Has a closure (9th Grade)	26,290	0.104	0.306	0	1
Voluntary Mover (9th Grade)	26,290	0.494	0.500	0	1
Fraction Students from Closed Schools	98,696	0.019	0.051	0	0.75
Fraction Students New to School	98,696	0.428	0.250	0	1
Number of Students	26,286				
Number of Schools	124				

Notes: Variables under the heading "Demographics" and "Academic Outcomes" are based on student-year observations. Estimates under "Graduation and College" and "Mobility and Closures" are calculated at a single student observation with the exception of fraction of students new to school which is also student-year.

Table 2: Descriptive Statistics of Students With and Without Closures, Pre-Closure

	8th Grade			9th Grade		
	Never Close	Pre-Closure	Difference	Never Close	Pre-Closure	Difference
Attendance	0.900	0.855	-0.045***	0.847	0.774	-0.072***
GPA	2.388	1.951	-0.437***	1.963	1.512	-0.452***
Discipline Incidents	2.855	4.352	1.497***	3.542	4.335	0.793***
Suspensions	1.282	2.096	0.813***	1.694	2.309	0.615***
Female	0.500	0.486	-0.014	0.497	0.486	-0.011
Free/Reduced Lunch	0.770	0.837	0.067***	0.756	0.815	0.058***
English Language Learner	0.074	0.025	-0.05***	0.073	0.023	-0.05***
Disability	0.197	0.275	0.078***	0.191	0.260	0.069***
White	0.115	0.054	-0.061***	0.111	0.054	-0.058***
Black	0.601	0.800	0.199***	0.608	0.798	0.19***
Hispanic	0.204	0.098	-0.106***	0.200	0.099	-0.101***
Asian	0.053	0.023	-0.030***	0.052	0.022	-0.030***
Attend Local School	0.152	0.164	0.012	0.098	0.063	-0.036
WKCE Math	0.100	-0.322	-0.422***	-	-	-
WKCE Reading	0.089	-0.308	-0.397***	-	-	-
N	~19,000	~2,100		~23,000	~2,600	

Notes: Estimated means for the 2005-06 to 2009-10 freshmen cohorts. "Never Close" refers to students who never have a school closure while observed in the data set. "Pre-Closure" refers to students who have a closure, but that occurs after the 9th grade.

Table 3: Characteristics of Schools Attended Before and After School Closure

	Before Closure School Mean	After Closure School Mean	Full Sample School Mean
WPI Data			
Enrollment	399.81	765.78	1122.01
Attendance Percent	75.82	77.35	81.80
Graduation Rate	64.21	67.21	77.72
10th Grade WKCE Math			
% Minimum	41.62	38.71	26.25
% Basic	27.06	27.38	25.41
% Proficient	15.91	20.17	27.43
% Advanced	5.35	6.73	15.29
10th Grade WKCE Reading			
% Minimum	56.16	56.52	41.90
% Basic	18.57	20.23	21.53
% Proficient	13.45	15.78	27.86
% Advanced	0.28	0.97	3.66
Charter School	0.52	0.25	0.14
MPS Data			
Attendance Percent	0.72	0.74	0.80
GPA	1.63	1.67	1.90
Discipline Incidents	2.87	2.96	2.59
10th Grade WKCE Math	-0.47	-0.33	-0.06
10th Grade WKCE Read	-0.47	-0.32	-0.05
Free/Reduced Lunch	0.83	0.81	0.75
Disability	0.27	0.24	0.21
English Language Learner	0.01	0.07	0.07
Local School	0.04	0.07	0.09

Notes: Reported means are weighted by student enrollment. "Before Closure Means" are calculated based on the school average the year prior to closure. "After Closure" means are calculated on lagged values the year after closure. "Full Sample Means" are calculated using all schools across all years excluding students who have a closure.

Table 4: Difference-in-Difference Estimates of School Closings

	GPA (1)	Attendance Fraction (2)	Discipline Incidents (3)	Number of Suspensions (4)
Post-Closure	-0.168**	-0.032***	-0.003	-0.149
	(0.070)	(0.010)	(0.394)	(0.199)
Post-Voluntary Move	0.087***	-0.008	-1.606***	-0.835***
	(0.024)	(0.005)	(0.229)	(0.111)
Fraction of Students from Closed Schools	0.245*	0.006	0.317	0.399
x (Indiv. From Closed School)	(0.139)	(0.043)	(0.865)	(0.409)
Fraction of Students from Closed Schools	0.308*	-0.070*	-1.062	-1.152*
x (Indiv. Not From Closed School)	(0.162)	(0.040)	(2.044)	(0.666)
Fraction of New (Non-Closure) Students	0.709***	0.074***	-3.595***	-1.441***
	(0.103)	(0.020)	(0.638)	(0.287)
N	92,221	96,049	96,058	96,058

Notes: All coefficients are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts. All regressions also include indicators for student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Standard errors in parentheses are multi-way clustered at the 9th grade school and current school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 5: Difference-in-Difference Estimates (8th vs 10th Grade)

	Math Test (1)	Reading Test (2)	GPA (3)	Attendance Percent (4)	Discipline Incidents (5)	Number of Suspensions (6)
Post-Closure	-0.038	0.041	-0.073	-0.037***	0.001	0.158
	(0.052)	(0.050)	(0.060)	(0.011)	(0.332)	(0.158)
Post-Voluntary Move	-0.025	-0.067***	-0.040*	-0.030***	-0.657***	-0.181**
	(0.021)	(0.018)	(0.022)	(0.007)	(0.208)	(0.091)
Fraction of Students from Closed Schools	-0.373*	-0.458*	0.385*	-0.060	-1.025	-0.919
x (Indiv. From Closed School)	(0.215)	(0.235)	(0.212)	(0.063)	(1.872)	(0.942)
Fraction of Students from Closed Schools	-0.481**	-0.658**	0.361	-0.278***	-3.699**	-2.576***
x (Indiv. Not From Closed School)	(0.215)	(0.266)	(0.261)	(0.086)	(1.637)	(0.865)
Fraction of New (Non-Closure) Students	-0.090*	-0.045	0.490***	0.034**	-0.945**	-0.268
	(0.048)	(0.044)	(0.115)	(0.016)	(0.405)	(0.182)
N	35,085	34,905	33,845	40,311	40,311	40,311

Notes: All coefficients are estimated using 8th and 10th grade observations of the 2005-06 to 2009-10 freshman cohorts. All regressions also include student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Standard errors in parentheses are clustered at the 9th grade school level.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 6: Event Study Estimates of School Closings

	GPA (1)	Attendance Percent (2)	Discipline Incidents (3)	Number of Suspensions (4)
3+ Years Before Closure	-0.041	0.016	-0.292	-0.230
	(0.094)	(0.013)	(0.407)	(0.221)
2 Years Before Closure	-0.006	0.015*	0.217	0.025
	(0.068)	(0.009)	(0.411)	(0.213)
1 Year Before Closure	-	-	-	-
1 Year After Closure	-0.166**	-0.030***	0.330	-0.083
	(0.073)	(0.009)	(0.444)	(0.252)
2 Years After Closure	-0.186**	-0.029**	-0.211	-0.197
	(0.089)	(0.012)	(0.429)	(0.244)
3+ Years After Closure	-0.159	-0.011	-0.190	-0.298
	(0.102)	(0.016)	(0.515)	(0.267)
N	92,221	96,049	96,058	96,058

Notes: All coefficients are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts. All regressions also incldue the fraction of students new to the school each year as well as the fraction of students from closed schools interacted with an indicator if the student was from a closure school themselves. Whether the student has moved voluntarily and if they were part of a school merger are also included. Regressions also include indicators for student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Standard errors in parentheses are multi-way clustered at the 9th grade school and current school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 7: Effects of High School Closures on Educational Attainment

Panel A: High School Graduation Outcomes

	Graduate High School	Graduate High School On Time	Graduate High School (12th Graders)
Student Has Closure	-0.093***	-0.094***	-0.058***
	(0.032)	(0.031)	(0.020)
N	12,804	12,804	7,609

Panel B: College Attendance Outcomes - High School Graduates Only

	College Attendance	2-Year College Attendance	4-Year College Attendance
Student Has Closure	-0.027	-0.032**	0.005
	(0.029)	(0.016)	(0.027)
N	7,725	7,725	7,725

Panel C: College Attendance Outcomes - All Students (Imputed)

	College Attendance	2-Year College Attendance	4-Year College Attendance
Student Has Closure	-0.048**	-0.036***	-0.015
	(0.020)	(0.010)	(0.015)
N	12,804	12,804	12,804

Notes: All coefficients are estimated using students from the 2005-06 to 2009-10 freshman cohorts. In Panel A the first two columns contain all freshmen while the third contains the subset that reach 12th grade. Estimates in Panel B are only calculated using high school graduates. Estimates in Panel C are calculated on all students and assumes that non-high school graduates do not attend college. All regressions also include student demographics, 8th and 9th grade student achievement, lagged 9th grade school characteristics, cohort fixed effects, and 8th grade school fixed effects. Standard errors in parentheses are clustered at the school level.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 8: Effects of High School Closures on Educational Attainment by Grade of Closure

	High School Graduation			*College Attendance - HS Grads*			*College Attendance - All Students (Imputed)*		
	Graduate	Graduate On Time	12th Grade Graduation	College Attendance	2-Year College Attendance	4-Year College Attendance	College Attendance	2-Year College Attendance	4-Year College Attendance
Student Has Closure in 9th Grade	-0.131***	-0.120***	-0.043	-0.071	-0.023	-0.043	-0.032*	-0.033***	0.002
	(0.032)	(0.031)	(0.040)	(0.051)	(0.027)	(0.041)	(0.018)	(0.010)	(0.017)
Student Has Closure in 10th Grade	-0.075**	-0.092***	-0.022	-0.054	-0.072**	0.023	-0.060**	-0.048***	-0.010
	(0.036)	(0.033)	(0.033)	(0.046)	(0.027)	(0.042)	(0.025)	(0.013)	(0.020)
Student Has Closure in 11th Grade	-0.077	-0.075	-0.093***	0.006	-0.009	0.008	-0.061*	-0.031	-0.034
	(0.051)	(0.051)	(0.032)	(0.042)	(0.029)	(0.032)	(0.034)	(0.020)	(0.021)
N	12,804	12,804	7,609	7,725	7,725	7,725	12804	12804	12804

Notes: All coefficients are estimated using students from the 2005-06 to 2009-10 freshman cohorts. The first two columns contain all freshmen while the third contains the subset that reach 12th grade. The next 3 columns are only calculated using high school graduates. The final 3 columns are calculated on all students and assumes that non-high school graduates do not attend college. All regressions also include student demographics, 8th and 9th grade student achievement, lagged 9th grade school characteristics, cohort fixed effects, and 8th grade school fixed effects. Standard errors in parentheses are clustered at the school level.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 9: Estimates of School Closure by Quality of Receiving School

Panel A: Difference-in-Differences Estimates of Achievement

Achievement Outcomes	GPA	Attendance Percent	Discipline Incidents	Number of Suspensions
Post-Closure	-0.235***	-0.027***	-0.030	-0.117
x (School has Higher Combined WKCE)	(0.060)	(0.010)	(0.400)	(0.188)
Post-Closure	-0.095	-0.038***	0.026	-0.184
x (School has Lower Combined WKCE)	(0.099)	(0.014)	(0.515)	(0.297)

Panel B: OLS Estimates of Attainment

Attainment Outcomes	Graduate	Graduate On Time	12th Grade Graduation	College Attendance	2-Year College Attendance	4-Year College Attendance
Student Has Closure	-0.054*	-0.055*	-0.075**	-0.071*	-0.059*	-0.019
x (School has Higher Combined WKCE)	(0.028)	(0.030)	(0.029)	(0.039)	(0.035)	(0.026)
Student Has Closure	-0.109***	-0.110***	-0.048	-0.004	-0.018	0.018
x (School has Lower Combined WKCE)	(0.040)	(0.039)	(0.029)	(0.036)	(0.021)	(0.036)

Notes: Coefficients in Panel A are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts and include controls for fraction of students new to the school and from closure schools, demographic controls and student and grade-by-year fixed effects. Coefficients in Panel B are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts and include student demographics, 8th and 9th grade achievement, lagged 9th grade school characteristics, cohort fixed effects, and 8th grade school fixed effects . Standard errors in parentheses are clustered at the school level.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 10: Pre-Closure Effects on Mobility

	In MPS the Following Year		*In New School the Following Year*	
	9th Grade	10th Grade	9th Grade	10th Grade
School Closes in 2 Years	0.008	-0.019	0.018	0.041*
	(0.013)	(0.016)	(0.031)	(0.024)
School Closes at End of Yea	-0.077	-0.089**	0.750***	0.730***
	(0.052)	(0.044)	(0.022)	(0.019)
N	20,296	18,180	19,328	16,906

Notes: All coefficients are estimated using students from the 2005-06 to 2009-10 freshman cohorts. All regressions also include student demographics, 8th and 9th grade student achievement, cohort fixed effects, and 8th grade school fixed effects. Standard errors in parentheses are clustered at the school level.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 11: Difference-in-Difference Estimates of School Closings Weighted by Attrition

	GPA (1)	Attendance Fraction (2)	Discipline Incidents (3)	Number of Suspensions (4)
Post-Closure	-0.139**	-0.027**	0.233	-0.089
	(0.066)	(0.010)	(0.480)	(0.235)
Post-Voluntary Move	0.111***	0.006	-1.882***	-0.971***
	(0.017)	(0.005)	(0.276)	(0.130)
Fraction of Students from Closed Schools	0.228	-0.000	0.248	0.401
x (Indiv. From Closed School)	(0.177)	(0.054)	(1.067)	(0.439)
Fraction of Students from Closed Schools	0.254	-0.067*	-0.945	-1.211*
x (Indiv. Not From Closed School)	(0.158)	(0.040)	(2.120)	(0.728)
Fraction of New (Non-Closure) Students	0.750***	0.116***	-4.289***	-1.702***
	(0.104)	(0.024)	(0.633)	(0.312)
N	91,927	95,275	95,284	95,284

Notes: All coefficients are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts. All regressions also include indicators for student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Estimates are weighted by the inverse probability of attrition. Standard errors in parentheses are multi-way clustered at the 9th grade school and current school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 12: Effects of High School Closures on Educational Attainment (Cohort Level Difference-in-Differences)

Panel A: High School Graduation Outcomes						
	Graduate		Graduate On Time		12th Grade Graduation	
Closure Treated Cohort	-0.083	-0.075	-0.088	-0.077	0.014	0.012
	(0.063)	(0.069)	(0.064)	(0.070)	(0.039)	(0.030)
N	324	312	324	312	273	264
Mean Outcome	0.634		0.584		0.897	
Panel B: College Attendance Outcomes - High School Graduates Only						
	College Attendance		2-Year College Attendance		4-Year College Attendance	
Closure Treated Cohort	-0.084*	-0.098**	-0.044*	-0.053*	-0.045	-0.053
	(0.043)	(0.041)	(0.024)	(0.027)	(0.042)	(0.045)
N	269	261	269	261	269	261
Mean Outcome	0.579		0.209		0.368	
Panel C: College Attendance Outcomes - All Students (Imputed)						
	College Attendance		2-Year College Attendance		4-Year College Attendance	
Closure Treated Cohort	-0.054	-0.050	-0.027	-0.025	-0.028	-0.027
	(0.041)	(0.045)	(0.020)	(0.021)	(0.027)	(0.030)
N	324	312	324	312	324	312
Mean Outcome	0.368		0.132		0.234	
Cohort Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
School/Cohort Demographics	No	Yes	No	Yes	No	Yes
School/Cohort 8th Grade Perf.	No	Yes	No	Yes	No	Yes

Notes: All coefficients are estimated using students from the 2005-06 to 2009-10 freshman cohorts. In Panel A the first two columns contain all freshmen while the third contains the subset that reach 12th grade. Estimates in Panel B are only calculated using high school graduates. Estimates in Panel C are calculated on all students and assumes that non-high school graduates do not attend college. Standard errors in parentheses are clustered at the school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Figure 1A: Event Study of School Closure on GPA

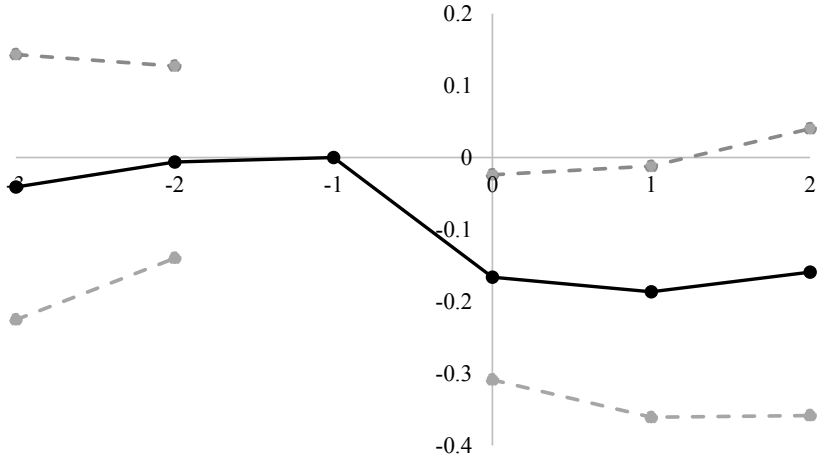


Figure 1B: Event Study of School Closure on Attendance

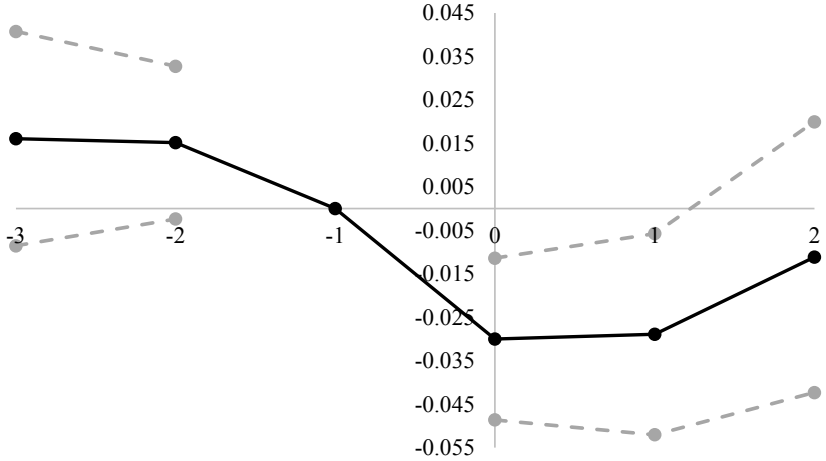


Figure 1C: Event Study of School Closure on Discipline Incidents

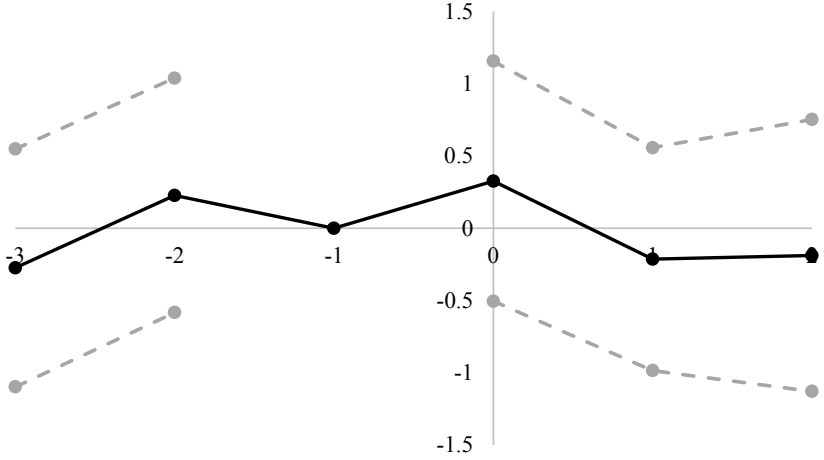


Figure 1D: Event Study of School Closures on Suspensions

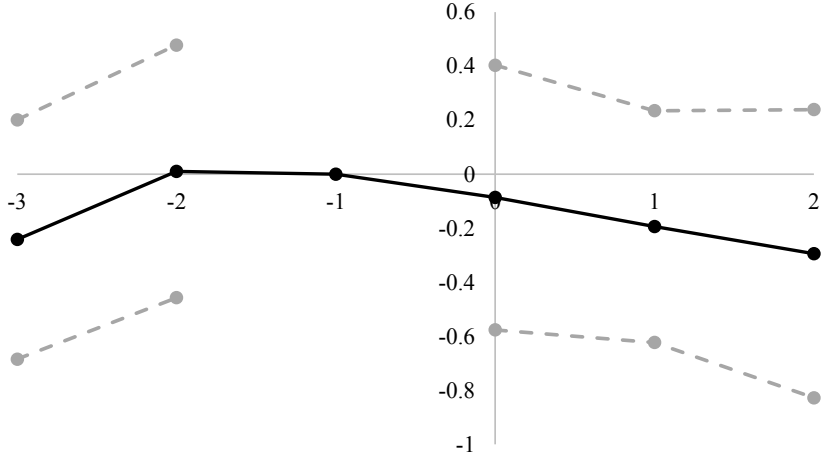


Figure 2A: Event Study of School Closure on GPA

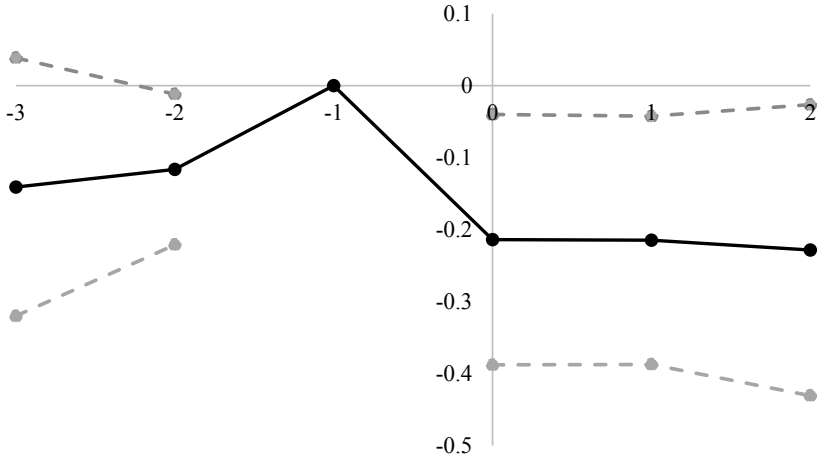


Figure 2B: Event Study of School Closure on Attendance

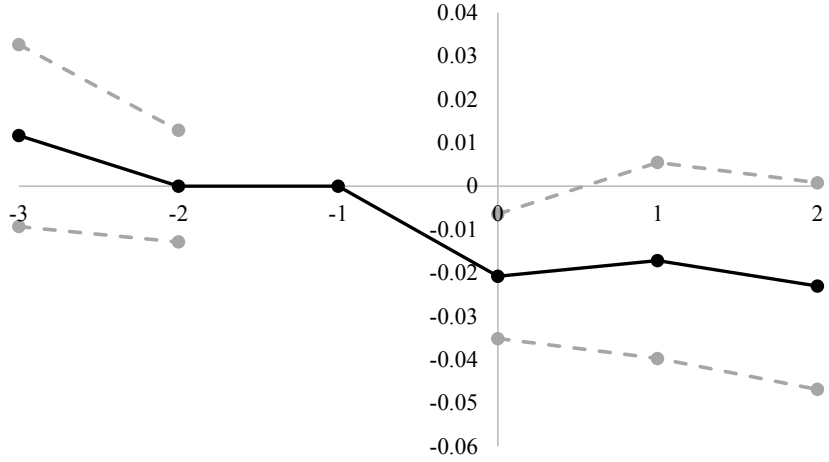


Figure 2C: Event Study of School Closure on Discipline Incidents

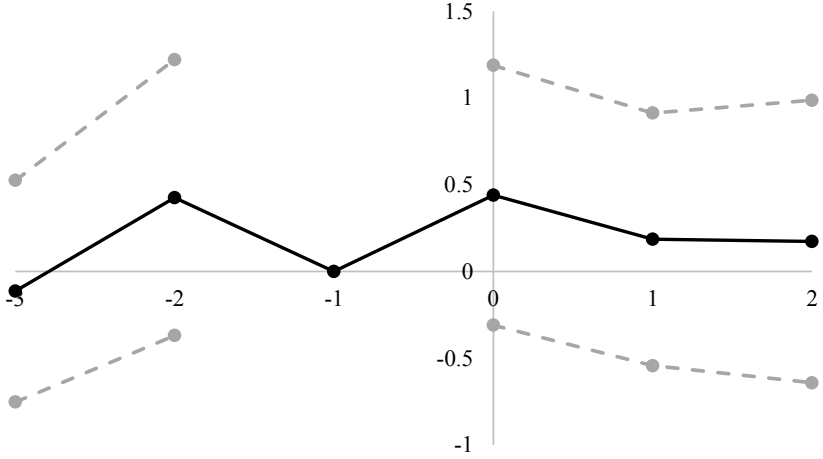


Figure 2D: Event Study of School Closures on Suspensions

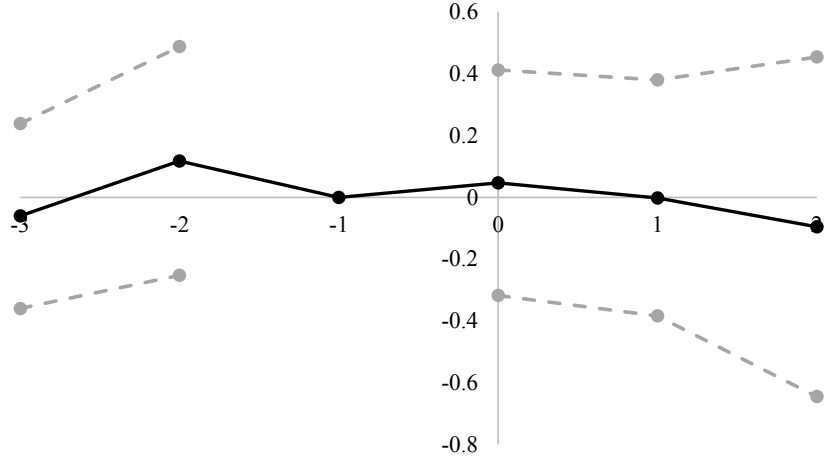


Figure 3A: Event Study of School Closure on GPA by Grade of Closure

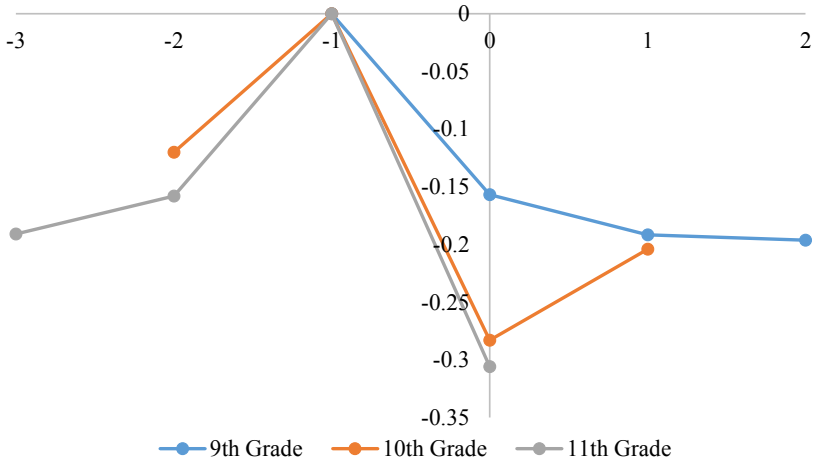


Figure 3B: Event Study of School Closure on Attendance by Grade of Closure

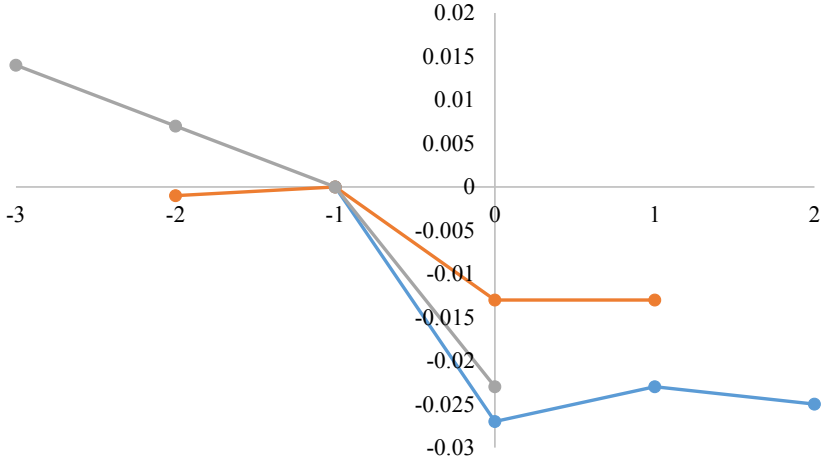


Figure 3C: Event Study of School Closure on Discipline Incidents by Grade of Closure

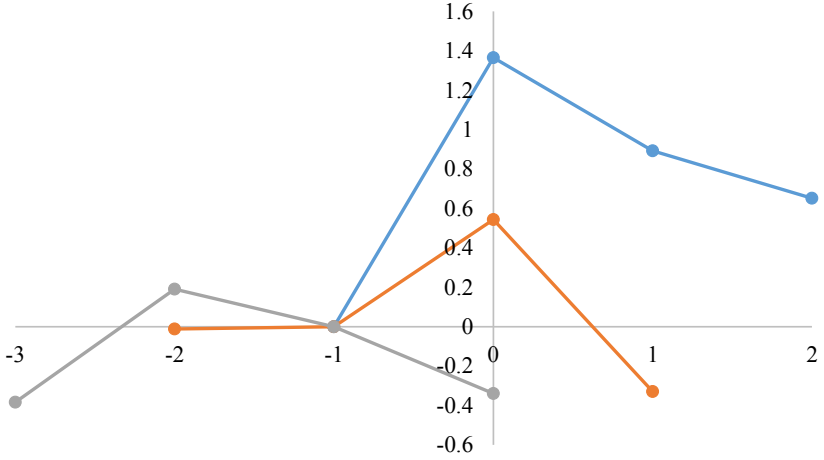
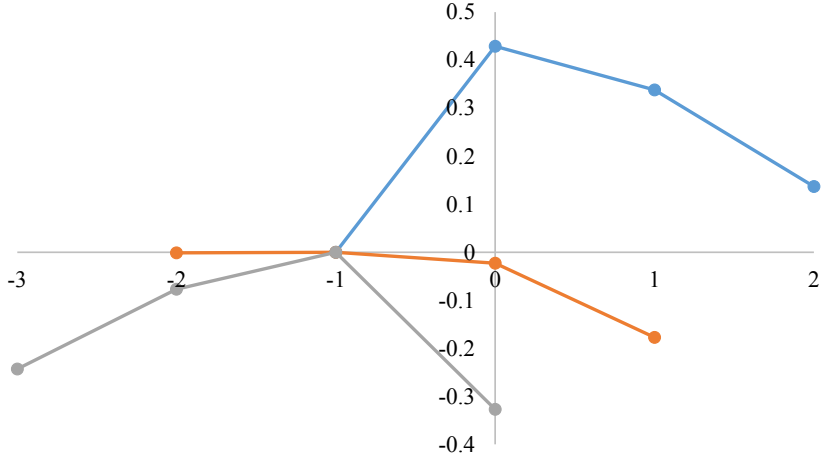


Figure 3D: Event Study of School Closures on Suspensions by Grade of Closure



Appendix Table 1: Number of School Closings in Milwaukee by Year

School Year	Number of Closures	Number of Closures covering high school grades
2001-02	2	0
2002-03	0	0
2003-04	2	0
2004-05	6	3
2005-06	6	2
2006-07	10	5
2007-08	9	3
2008-09	3	1
2009-10	13	8
2010-11	10	5
2011-12	11	9
2012-13	8	5
Total	80	41
Total after 2005	64	36

Appendix Table 2: Difference-in-Difference Estimates of School Closings (2007-2009 Freshmen Cohorts)

	GPA (1)	Attendance Fraction (2)	Discipline Incidents (3)	Number of Suspensions (4)
Post-Closure	-0.117	-0.023***	-0.349	-0.493**
	(0.081)	(0.008)	(0.492)	(0.203)
Post-Voluntary Move	0.064**	-0.007	-1.887***	-0.910***
	(0.025)	(0.005)	(0.230)	(0.096)
Fraction of Students from Closed Schools	0.169	-0.005	0.337	0.499**
x (Indiv. From Closed School)	(0.133)	(0.037)	(0.628)	(0.245)
Fraction of Students from Closed Schools	0.231	-0.079	-0.230	-0.763
x (Indiv. Not From Closed School)	(0.209)	(0.050)	(2.118)	(0.511)
Fraction of New (Non-Closure) Students	0.704***	0.082***	-4.022***	-1.562***
	(0.103)	(0.023)	(0.678)	(0.257)
N	55,968	58,441	58,450	58,450

Notes: All coefficients are estimated using 9th-12th grade observations of the 2007-08 to 2009-10 freshman cohorts. All regressions also include indicators for student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Standard errors in parentheses are multi-way clusted at the 9th grade school and current school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Appendix Table 3: Difference-in-Difference Estimates of School Closings (Only Includes Students with a Closure)

	GPA	Attendance Fraction	Discipline Incidents	Number of Suspensions
Post-Closure	-0.227***	-0.037***	-0.053	-0.167
	(0.071)	(0.013)	(0.406)	(0.241)
Post-Voluntary Move	0.093*	-0.001	-1.854***	-0.813***
	(0.049)	(0.009)	(0.396)	(0.190)
Fraction of Students from Closed Schools x (Indiv. From Closed School)	0.233	-0.005	0.290	0.371
	(0.176)	(0.038)	(0.711)	(0.323)
Fraction of Students from Closed Schools x (Indiv. Not From Closed School)	-0.012	-0.174***	-0.896	-0.779
	(0.243)	(0.038)	(1.293)	(0.799)
Fraction of New (Non-Closure) Students	0.296**	0.025	-1.964***	-0.612*
	(0.141)	(0.023)	(0.666)	(0.325)
N	7,378	7,688	7,688	7,688

Notes: All coefficients are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts and is limited to the subset of students who experience a closure. All regressions also include indicators for student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Standard errors in parentheses are multi-way clusted at the 9th grade school and current school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Appendix Table 4: Event Study Estimates of School Closings - Balanced Panel

	GPA	Attendance Percent	Discipline Incidents	Number of Suspensions
3+ Years Before Closure	-0.141	0.012	-0.113	-0.060
	(0.091)	(0.011)	(0.326)	(0.153)
2 Years Before Closure	-0.116**	-0.000	0.427	0.118
	(0.053)	(0.007)	(0.406)	(0.189)
1 Year Before Closure	-	-	-	-
1 Year After Closure	-0.214**	-0.021***	0.440	0.047
	(0.089)	(0.007)	(0.382)	(0.186)
2 Years After Closure	-0.215**	-0.017	0.186	-0.002
	(0.088)	(0.012)	(0.372)	(0.195)
3+ Years After Closure	-0.228**	-0.023*	0.173	-0.095
	(0.103)	(0.012)	(0.416)	(0.281)
N	57,013	57,943	57,945	57,945

Notes: All coefficients are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts. The sample is limited ot the 4 years following the student freshman year. It is also limited to students who attend in MPS school for all 4 years and who are not held back in any grades. All regressions also include the fraction of students new to the school each year as well as the fraction of students from closed schools interacted with an indicator if the student was from a closure school themselves. Whether the student has moved voluntarily and if they were part of a school merger are also included. Regressions also include indicators for student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Standard errors in parentheses are multi-way clustered at the 9th grade school and current school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Appendix Table 5: Event Study Estimates of School Closings by Grade of Closure - Balanced Panel

	GPA			Attendance Percent			Discipline Incidents			Number of Suspensions		
	9th Grade Closure	10th Grade Closure	11th Grade Closure	9th Grade Closure	10th Grade Closure	11th Grade Closure	9th Grade Closure	10th Grade Closure	11th Grade Closure	9th Grade Closure	10th Grade	11th Grade
3+ Years Before Closure	-	-	-0.174	-	-	0.014	-	-	-0.383	-	-	-0.227
			(0.113)			(0.013)			(0.314)			(0.141)
2 Years Before Closure	-	-0.118*	-0.140	-	-0.002	0.007	-	0.013	0.198	-	0.016	-0.060
		(0.060)	(0.098)		(0.006)	(0.011)		(0.439)	(0.579)		(0.245)	(0.194)
1 Year Before Closure	0	0	0	0	0	0	0	0	0	0	0	0
1 Year After Closure	-0.157	-0.281**	-0.303***	-0.027***	-0.013	-0.023	1.373**	0.554	-0.345	0.431	-0.017	-0.325**
	(0.116)	(0.123)	(0.100)	(0.009)	(0.017)	(0.015)	(0.657)	(0.425)	(0.401)	(0.330)	(0.225)	(0.165)
2 Years After Closure	-0.192*	-0.204**	-	-0.023**	-0.013	-	0.883	-0.308	-	0.330	-0.175	-
	(0.113)	(0.094)		(0.010)	(0.017)		(0.539)	(0.288)		(0.312)	(0.194)	
3+ Years After Closure	-0.196	-	-	-0.025**	-	-	0.637	-	-	0.128	-	-
	(0.127)			(0.011)			(0.531)			(0.340)		
N	54,773	54,796	54,602	55,673	55,701	55,519	55,675	55,703	55,521	55,675	55,703	55,521

Notes: All coefficients are estimated using 9th-12th grade observations of the 2005-06 to 2009-10 freshman cohorts and each column represents a separate regression. The sample is limited ot the 4 years following the student freshman year. It is also limited to students who attend in MPS school for all 4 years and who are not held back in any grades. All regressions also include the fraction of students new to the school each year as well as the fraction of students from closed schools interacted with an indicator if the student was from a closure school themselves. Whether the student has moved voluntarily and if they were part of a school merger are also included. Regressions also include indicators for student free/reduced price lunch status, disability status, and english language learner status as well as full sets of student and grade-by-year fixed effects. Standard errors in parentheses are multi-way clustered at the 9th grade school and current school.

*** Significant at 1%, ** Significant at 5%, * Significant at 10%