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. I find that on average school closings cause a negative shock to students, lowering their GPA and attendance. There is evidence that this effect lessens overtime, however, for many students, high school ends before the effects can completely be reversed. The closures also lower the probability of high school graduation and college attendance suggesting that the effects of these closures can be long lasting and have important long-term consequences.

Preliminary Results. Please do not cite without author's permission.

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1. Introduction

School closures are common across the United States, yet they are always controversial. Chicago and Philadelphia school districts made headlines last year after announcing the closure of 47 and 23 schools respectively, some of the largest single closures in US history.[3] Across the US 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). Announcements of school closings are almost always met with strong opposition from parents, students, teachers, and administrators alike. Parents relate closing schools to closing communities and worry about the effect on their children, teachers worry about their jobs, and students are concerned with being removed from their friends, teachers, and routines they have become comfortable with. Even people in non-closed schools worry about consequences of the sudden flow of students to their classrooms. While almost everyone worries about the burden that school closings will place on them, there is only a small amount of empirical research into what the true effects of the closures are. In this paper I contribute to that literature by estimating the effects of high school closures on the achievement and educational attainment of the students affected.

School closures can occur for a variety of reasons, but the two most common are under-utilization (under enrollment) and consistent poor performance. While each is important the reasoning behind the closures is very different. Schools that are under-utilized are often not running efficiently. Even schools that are not full still often have to pay full (or near full) costs on maintenance, facilities, administration, transportation, security, and several other inputs. At the same time it is difficult to offer specialized

[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

services in an under-utilized school because there are often are not enough students to justify the high fixed costs. When school districts are under fiscal stress, often the path of least resistance is closing the most under-enrolled schools. By closing down these underutilized, inefficient schools, the district can redistribute the savings to other schools resulting in a more efficient, "better" school district.

The reason behind closing poor performing schools is more obvious. If the schools are not meeting academic standards, then policymakers believe students are better off if the schools are closed and students attend new or different schools.[4] If these poor performing schools are not closed, parents may choose to "vote with their feet" by moving to a new catchment zone or district, or enrolling their children in private or home school. As more and more parents choose these options, the school can become under-utilized and eventually close anyway.

Both of these reasons are likely to become more prominent as many researchers and policymakers advocate competition as a way to improve school quality (Hoxby 2003). The implementation of choice such as charter schools, open enrollment schools, or voucher programs work to improve quality by increasing competitive pressure in the district. One key component of competition is that entry and exit needs to be a real possibility. As school districts adopt more competition in their schools, more schools will necessarily be closed, affecting more students. Thus, it is important to work to understand the full effects of these closings as these policies become more prevalent.

[4] There are, of course, other options such as replacing the administration. There also can be a discrepancy between what parents, teachers, and administrators deem important. Many parents may be quite happy with the performance of their "failing" school.

There are many theoretical effects of school closures on students. The closure itself can act as a disruption to a student's learning environment. Students are often separated from the peers, teachers, and administrators that they have become comfortable with (even if they were not necessarily learning much). They will have to learn and adjust to the rules, requirements, and layout of their new school. Many students will likely have to travel further to school, which may separate them from neighborhood friends 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.

On the other hand, school quality should theoretically increase for students after a closure. 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 school 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 likely positively affect students.[5]

Previous research has shown that likely all of these theories are valid. Most studies find an immediate post-closure drop in achievement followed by a steady increase, sometimes exceeding pre-closure achievement levels.[6] This result suggests that any negative effects are temporary and, in many cases, students are better off in the long

[5] 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.
[6] Brummett (2012); De la Torre and Gwynne (2009); and Sacerdote (2012) all find some form of a sudden shock followed by a return towards pre-closure levels of achievement.

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 become more important. For example, high school closures might be much more likely to cause harm than elementary or middle school closures.

In this paper I estimate the effect of 33 high school closures, specifically, the effect of high school closings on achievement (GPA, attendance, test scores, and discipline) and educational attainment (high school graduation and college attendance). These student-level microdata data cover a seven-year period including five different freshman cohorts in the Milwaukee Public School district. Using a difference-in-differences estimations strategy 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. I also 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, attendance, and suspensions are all negatively affected in the short term. Standardized test scores are not significantly affected, but this is due at least partly to lower statistical power for that variable. The negative effects on GPA and attendance fade over time, but the levels of these variables only start to reach the levels of the comparison group three years after the closure, which, for many students, is past the point they would be enrolled in high school. Due to these effects, and potentially other unmeasured effects, students who experience a closure while in high school are less likely to graduate high school and less likely to attend college. The results are robust to weighting by the probability of attrition and are

consistent whether the student attends a high quality school after closure or 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. However, especially at the high school level, these benefits may never arise for current students. This may be judged a worthwhile sacrifice, given the potential benefits for future generations of students, but the costs can be great.

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 a conclusion in section 7.

2. Previous Literature

With an increase in school closings across the US, the school closing literature has also grown. Most studies have focused on the more common elementary school closings and their effects on standardized test scores as a measure of achievement. For example, Brummet (2012) estimates the effects of over 200 school closings across the state of Michigan. He finds that school closures cause a temporary decline in math test scores that begins up to two years before the school actually closes. He also finds that the flow of new students and teachers into receiving schools has a negative impact on the achievement of non-closure students. De la Torre and Gwynne (2009) find transitory reductions in test scores after school announcements in Chicago, but not after the closures themselves. They also observe an increase in voluntary mobility following relocation. Engberg et al. (2012) study the restructuring of an urban school district that resulted in 20

school closures in an attempt to move students to better quality schools. They find that closures do lead to decreases in standardized test scores, but that students moving to higher quality schools are not significantly affected by the closure.

Sacerdote (2012) looks at high school closures in Louisiana due to Hurricanes Katrina and Rita. Like the previous papers, he finds that relocated students do worse on standardized tests immediately after a closure but end up back on trend or better a few years later. He also finds that New Orleans evacuees have lower college attendance rates than the non-evacuated cohorts from the same school, but that evacuees from other areas of Louisiana are more likely to attend college. In a related paper, Imberman et al. (2012) estimate the spillover effect of evacuees on the schools receiving evacuees. They do not find significant average effects on the test scores of receiving school peers nor on discipline and attendance. One limitation of these studies is that it is not possible to separate the effects of the school closure from other potential effects of the storms. For this reason, the results may not be generalizable to the school closings examined in this paper.

A related literature examines the impact of student mobility in general. 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 .05 to .1 standard deviation decrease in test scores. Hanushek, Kain, and Rivkin (2004) and Xu, Hannaway, and D'Souza (2009) similarly study mobility in Texas and North Carolina respectively. These studies find negative effects on achievement following moves within a district, but insignificant effects for moves across districts.

3. Milwaukee School Closings

The Milwaukee Public School (MPS) district is the largest public school district in Wisconsin and the 36th largest 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. Students' academic performance is relatively poor with standardized test scores well below the national average and graduation rates are the slightly above 60 percent. Of those graduates only about half continue on to college with about half of those students either attending the University of Wisconsin-Milwaukee (4 year) or Milwaukee Area Technical College (2 year), both of which are considered "non-competitive" (Carl et al. 2009).

What is unique about Milwaukee is its commitment to school choice. Milwaukee has district-wide open enrollment, which means that parents can choose almost any school in the district to attend (Eadie et al., 2013).[7] 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 operated by one of three entities:

[7] While students can choose almost any school, they are not guaranteed enrollment in any school. 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.

MPS, the University of Wisconsin-Milwaukee, or the city of Milwaukee. Finally, the Milwaukee Parental Choice Program was instituted in 1990, and is one of the nations first and largest voucher programs. This program provides vouchers for low-income students to enroll in eligible Milwaukee private schools. Due to these many options, Milwaukee students tend to be very mobile, with nearly 40% of students moving two times or more between the 2006-07 and 2010-11 school years (Eadie et al., 2013).

Partially due to changing demographics and partially due to increased enrollment in the voucher program and non-district charter schools, enrollment in MPS has declined in each of the last ten years leading to the closing of 80 schools over the decade.[8] In order to decide which schools to close, MPS utilizes a "school closing matrix." This matrix takes into account enrollment, academic performance, and a few other miscellaneous factors to determine which schools should be closed.[9] Around December these schools are announced to the general public, allowing board members, parents, and students time 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 in the summer.

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 very few other options—either pay for a private school or move to another catchment zone, both of which can be very costly. When

[8] See appendix table 1 for a tally of closed schools by year.
[9] The miscellaneous factors usually refer to facility needs such as structural issues that may require funding to fix.

schools are closed in these districts, students are usually re-assigned to other schools nearby. Families that are unhappy with their school but otherwise unable to make a change may welcome the reassignment.

In an open enrollment district, students are already able to change schools at very little cost. In an extreme example with perfect information and without capacity constraints, all students will be attending their first best choice school (subject to a travel costs). A school closure in this scenario will then necessarily move students from their top choice to their second best choice school, decreasing overall utility. Even without these extreme assumptions, it is reasonable to believe that school closures are more likely to result in students moving to less desirable schools in open enrollment districts than in traditional districts. This implies that closures may have larger negative effects in districts with more choice.

At the same time, open enrollment districts tend to have high voluntary mobility. It is more common for students to change schools and, therefore, for teachers and students to have new students in their classes. In this case, the districts with choice may more easily adapt to the effects of a school closure. 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 effects found in this paper may not generalize to traditional school districts.

4. Data

The data for this project are primarily from the Milwaukee Public School district. These data include detailed microlevel student observations that track students as long as they are enrolled in MPS.[10] I have data for all MPS high school students (those in grades 9-12) from the 2005-06 to the 2012-13 academic years. The student data also contain their complete MPS academic history, though I only utilize back to their 8th grade record since utilizing any prior years will further limit the number or students I can study. 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 assuming they are not held back in any grade.

The MPS data contain demographic variables such as student birthdates, gender, race, free/reduced price lunch status, English language learner status, and disability information. Academic variables include student transcripts, which are used to create yearly GPA; attendance records, used to create the fraction of school days attended; and discipline records, used to create an annual count of discipline incidents and the number of suspensions received. 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.[11] For this paper I will only be utilizing the 8th and 10th grade test scores in math and reading. I have standardized these scores at the year, grade, and subject level to have mean 0 and variance 1.

[10] This includes all public schools in MPS as well as any of the 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).

[11] Some students may not take the exam if they are absent on test days or have certain learning disabilities.

Attainment data are collected by MPS from the National Student Clearinghouse (NSC). The NSC has enrollment and completion data for 91% of all US postsecondary students. 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 very rare in Milwaukee (Carl et al., 2009). The NSC data include information on high school graduation and college attendance.[12] The college attendance data contain the name of the college attended, whether it is a 2-year or 4-year college, whether it is a public or private, and whether the college was in-state or out of state.[13] These data are only available for students who received a diploma while enrolled in MPS. They are not yet available for the graduating class of 2012-13, which means analysis of these data will exclude the 2009-10 freshman cohort. Due to the fact that these are recent high school graduates I focus on information about the first college attended after high school.

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 present. I focus on true school closings rather than building moves or school mergers. Finally, I also collect school level data from the Wisconsin Department of Public Instruction (DPI). This includes yearly school enrollment, attendance percent, graduation rates, and 10th grade WKCE proficiency.

Summary statistics of all MPS variables are presented in Table 1. This includes data for 26,315 students across 89 different schools. The sample is highly disadvantaged with over 75% of students receiving a free or reduced price lunch. Approximately 60%

[12] The data do not differentiate between true high school diplomas and other nontraditional diplomas such as GEDs.
[13] College degree receipt data are also available, but not enough time has elapsed from high school graduation for this to be useful information.

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 63% of ninth graders and 88% of 12th graders graduate from high school. Nearly 56% of those students go on to attend some type of college (30% 2-year and 70% 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 yearly, allowing me to utilize 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 students. In this section I will separately describe each estimation strategy.

5.1. Estimation of Achievement

As discussed earlier, 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* any of them actually occur (i.e. in the 8th and 9th 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 students who did not face a closure. To implement this strategy I estimate the following regression equation:

$$Y_{ist} = \beta_1 AfterClose_{it} + \beta_2 AfterVolMove_{it} + \beta_3 FracCloseStud_{st} * 1[JustClose_{ist} = 1] + \beta_4 FracCloseStud_{st} * 1[JustClose_{ist} = 1] + \beta_5 FracNewStud_{st} + \beta_7 X_{ist} + \theta_i + \delta_{gt} + \varepsilon_{ist} \quad (1)$$

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.[14] To be counted as a closure, the school must close before the student reaches the high grade in that particular school. Similarly the year after closure must not be the students' first time in the low grade of the receiving schools. This is done in an attempt to ensure that the reason for moving is the school closure and not a move that would have occurred otherwise.

The variable $AfterVolMove_{it}$ is defined very similarly to *AfterClose* but for voluntary school moves rather than moves due to school closures. This again, does not include moves due to grade promotion and also excludes any move that is the result of

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

school closures.[15] The inclusion of this variable along with the closure variable allows me to estimate if voluntary movers are affected differently by changing schools than students forced to move due to a closure.

To control for potential spillover effects of closure students I include the variable $FracCloseStud_{st}$. This is 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. This is then interacted with indicator variables indicating if the student themselves are newly from a closed school. The interaction with non-closure students will help identify possible spillover effects of the closures on non-closure students. The interaction with closure students will help identify potential benefits of moving to a school with many other students who have been through a similar experience. Finally, $FracNewStud_{st}$ is a measure of the fraction of new non-closure students in school *s* and year *t*. This will help control for the fact that both the direct and spillover effects of closure may be different if the school has a high fraction of new students.

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 helps control for the fact that achievement levels may be decreasing as students move through

[15] Results are robust to defining this variable as any non-closure move including promotions.

high school, as well control for any district wide changes in policies from year to year that may affect these outcomes.

5.2 Dynamic Estimation of Achievement

As Brummett (2012) and others have pointed out, understanding the dynamics of school closures is potentially just as important as finding their net effect. For one, it is possible that there are potential changes in achievement prior to the closure, as a result of anticipation of closure. Also, the effects of relocation may fade as the students adjust to their new school. In order to estimate these effects I adapt equation (1) into an event study and estimate the following equation:

$$Y_{ist} = \sum_{j=-3}^{2} \lambda_j Close_{itj} + \beta_2 AfterVolMove_{it} + \beta_3 FracCloseStud_{st} * 1[JustClose_{ist} = 1] + \beta_4 FracCloseStud_{st} * 1[JustClose_{ist} = 0] + \beta_5 FrscNewStud + \beta_7 X_{ist} + \theta_i + \delta_{gt} + \varepsilon_{ist} \quad (2)$$

In this equation $Close_{itj}$ is an indicator variable equal to1 if student *i* in year *t* experiences a closing *j* years from *t*.[16] 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.[17] The λ_j coefficients will allow me to identify the effect of closure up to three years before and three years after the closing

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

[17] 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.

(with j=0 being the year immediately after closing). All of the achievement regressions have standard errors clustered at the school level.[18]

5.3 Estimation of Attainment

The estimation of attainment 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 robust pre-closure demographics as well as 8th and 9th grade (pre-closure) achievement and 9th grade school characteristics.

$$Y_i = \beta_1 Close_i + \beta_2 X_i + 8thGrSchoolFE_i + 9thGrSchoolChar_i + Cohort_i \quad (3)$$

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 two measures of high school graduation: the "on-time" graduation rate[19], and the graduation rate of students who are observed in 12th grade. College level attainment variables are analyzed on the subset of students who graduate.

The variable $Close_i$ is an indicator variable equal to 1 if the student ever was relocated due to a high school closure and 0 otherwise. I no longer examine the effect of voluntary mobility because school closings have been shown to increase mobility and in

[18] The results are robust to clustering on 9th grade school rather than "current" school.
[19] "On-time" graduation is defined as any student who graduates within 4 years of their first-time freshman year.

this setting it is difficult to account for the timing of the two (de la Torre and Gwynne, 2009).[20] 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 lagged school level characteristics of a student's 9th grade school.[21] Taken together, these focus the comparison on students 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 controlling for changes over time as well as controlling for the fact that later cohorts have less time to attend college. All standard errors in the attainment regressions are clustered at the 9th grade school level.

6. Results

[20] Even though they are not included in my main specification results are robust to the inclusion of a voluntary movement indicator variable and available upon request. I also exclude any variables related to spillover effects of mobility. It is not clear exactly how spillovers would be measured here since classmates will change from year-to-year.

[21] 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.

Before examining the estimated effects, it is worth examining descriptive statistics on the types of schools being closed and the types of schools attended after closure. These statistics can be seen in table 3. The first column contains the school characteristics of the closed schools the year before closure.[22] 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.

As expected, recipient schools have much higher enrollments than closed schools—nearly twice as much. Recipient schools also perform much 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 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 average on almost all measures of academic success. Together, this demonstrates that while students are moving to "better" schools after closure, they are still attending relatively low quality schools. This is especially interesting considering that Milwaukee has an open enrollment policy. One potential reason is that students and parents care about school characteristics that are not captured in these measures. Another reason may be that it is difficult for students from closure schools to get into the top schools in the

[22] All means are weighted by school size.

district. Some 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: Difference-in-differences

Table 4 displays results from the estimation of equation 1. The first column estimates effects of closure on yearly GPA. Following a school closure students have a GPA that is 0.127 grade points lower than they would absent a closure. Relative to the average GPA of 1.9 this is approximately a 6.7% decrease in their GPA. On the other hand, students who voluntarily switch schools have a GPA that is 0.066 grade points higher than would otherwise. There are several possible reasons for this change 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 to be planned and potentially more targeted to increase achievement outcomes. Another possible reason for the decline is that the new schools grade more stringently than the closed schools, which would cause a decline in GPA without there being an effect on the students' effort or ability. To account for this possibility, I run the same regression but control for how easily each school grades their students.[23] When I do this I find a very similar and

[23] To do 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.

statistically significant effect of -0.151, suggesting that effect is not due to difference in grading rigor.[24] No matter the mechanism, the key for the students is that they will have a GPA that is nearly 7% 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 negatively affected by both closure related moves and voluntary moves, though the effect is larger for students relocated due to closures. A closure results in a 2.4 percentage point decrease in attendance. Relative to the MPS mandated minimum of 180 school days the closure results in approximately an extra 4.3 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 school. Students might skip school more often if they especially dislike 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 discipline. 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

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

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 the difficulty learning new rules may also lead to an increase in incidents after the closure.

While I am unable to separate out these effects, I do find that student both after closure and after voluntary moves have fewer discipline incidents and suspensions. The effects for voluntary movers are about twice as large as those students who are relocated due to closures. Voluntary movers have an average of 1.2 fewer incidents and 0.6 fewer suspensions following a closure, while closure students have a -0.5 and -0.4 fewer incidents and suspensions respectively. 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. At the same time they still benefit from the "fresh start" of moving to a new school. Students who go through a school closure may also be benefitting from the fresh start, but also are more likely to be frustrated that they have been forced to move to a new school. This could work to undo some (but not all) of the "fresh start" benefits to changing schools.

The analysis of WKCE test scores must be slightly modified from the previous method since the test is only taken in the 8^{th} and 10^{th} grades. To account for this I use a modified version of equation 1, where only the 8^{th} and 10^{th} grade observations are used in the analysis. This also means that the only high school closures that can be examined are those that occur before the 10^{th} grade. Results from this analysis 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, there is less power to identify significant effects across almost all outcomes as the number of closures has been significantly reduced. Though mostly insignificant, the effects on the original four achievement variables are consistent with their analysis on the full sample, with the possible exception of suspensions. The magnitude of closure effects on math test scores is consistent with the effects seen in other papers and like those papers the effect on reading test scores is small and insignificant. However, like most of the other variables the 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' performance.

Another key aspect of closures is that they bring a new population of students to non-closed schools. To examine this, I estimate the effect of the fraction of closure students on both closure and on non-closure students. I also examine the effect of having many new non-closure students. For all outcomes, the fraction of new, non-closure students in a school and year is positively 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 may 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.

In Table 3, the fraction of closure students at the school has either beneficial or insignificant spillover effects on the non-closure students as well as mostly positive effects on 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 joining a school 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 outcomes being examined here. GPA may increase, because teachers adjust their grading scales to account for the influx of students and the difficulties that come along with this. The results in Table 4 are consistent with this explanation of the inconsistencies. In this table, the spillover effects on test scores are negative and significant, while the spillover effects on GPA and discipline are beneficial.

6.2 Dynamic Achievement Effects

In order to observe how the effects of school closures change over time, I estimate equation 2. Results from this event study analysis of are presented in Table 6 and Figure 1. It is not possible to explore the effects of the WKCE exams in this way, so the results are limited to the initial four outcomes. Following convention, the interaction between school closure and the period immediately before closure is the omitted reference group. For GPA, there appears to be a pretty well defined break in trend after closure. Prior to closure, GPA was on a slight upward trend before dropping suddenly afterwards. The

second year after closure GPA continues to decrease slightly. By the third year after closure the estimates are returning towards their pre-closure levels. The point estimates are still negative, 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. While it is encouraging to see the estimates returning to zero, many students will not be enrolled long enough to make it to that point. Even if they are around long enough, the students' 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 as the environment around campus changes with the announcement of the closure, or it could be a simple trend. Either way, there is a much sharper decrease in attendance immediately after the closure. Like GPA, the effects stay below zero after closure and appear but return close to their pre-closure levels three years after the closure. Discipline variables show fairly consistent downward trends starting two years before closure. The slopes are relatively flat, with all point estimates being indistinguishable from one another. Together, these figures provide strong evidence that the effects seen on GPA and attendance are actually caused by the closure. They do not provide very convincing evidence that school closures have an effect on discipline.

6.3 Attainment Effects

Attainment effects are calculated on a variety of outcomes using estimation equation 3. I have also estimated this model using a propensity score nearest neighbor matching algorithm in addition to the standard OLS regressions. These results are presented in

Table 7. The first column estimates the effects on on-time graduation for all students in the sample.[25] The OLS results suggest a 3.2 percentage point decrease in the on-time graduation rate for students with closures. Relative to the mean on-time graduation rate of 64% for this sample, this represents approximately a 5% reduction in their graduation rate. The propensity score estimates are much smaller and insignificant, though not significantly different from the OLS results either. Column 2, displays results on the graduation rate for 12th graders. There is an approximate 7.5 to 8.3 percentage point decrease in the probability of graduation if the student has a closure. With the average around 90%, this represents approximately a 9% decrease in the 12th grade graduation rate.

The remaining columns are estimates of college enrollment. Of students that graduate, those who have school closures have approximately a 6 to 7.5 percentage point decrease in their probability of going to college (with a mean college attendance rate of 59%). This is primarily driven by a decrease in the two-year college attendance rate, which is likely because the type of student who will be attending 4-year colleges is both less likely to be affected by the closure and less likely to face a closure.

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.

6.4 Effect Heterogeneity

[25] Recall, all attainment estimates exclude the 2009-10 cohorts since attainment data were not made available for these students yet.

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, but nevertheless informative to examine. To do this, 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 signaling if the student attends a school with a better average WKCE math score, and an indicator signaling if the student attends a school with an equal or worse average score.[26] In the discussion below I will use "higher quality" to reference schools with higher average math scores and "lower quality" schools to reference schools with lower average math scores, realizing that this is not necessarily a direct measure of quality.

Table 9 estimates the heterogeneity of achievement and attainment using modified versions of equations 1 & 3. Interestingly, effects on GPA are large and negative for students who attend higher quality schools and small and positive for students that attend lower 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. Like achievement, most effects are statistically similar across school quality, with the lone exception being the 12th grade graduation rate.

[26] Effects are similar if the interaction uses WKCE reading scores instead of math scores and are available upon request.

Twelfth grade students are less likely to graduate if they attend a worse quality school after closure than if they attend a better quality school. While this effect is in the expected direction, it is somewhat surprising given that the achievement effects are not also worse for these students. However, better quality schools may do a better job of getting students to graduate, holding achievement constant.

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).[27] It is also likely that Milwaukee has more choice than the district studied in Engberg et al.[28] 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 by observable characteristics.

6.5 Attrition

There is potential concern that the effects found in this paper are driven partially by attrition. If school closings have an effect on attrition then the change in sample may

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

lead to changes in average attainment that are the result of sample composition rather than a direct effect. This is complicated by the fact that attrition in this case can be both students dropping out of high school as well as those moving to a non-district school. Each of these reasons for attrition can lead to very different compositions of the remaining students. To address some of this concern I follow Sacerdote (2012) and weight each regression by the propensity to leave the sample before 12th grade.[29]

Results of these weighted regressions are presented in Table 9. While a few effects like those on attendance and on-time graduation are no longer significant after weighting, none of the results are significantly different from their unweighted counterparts. This suggests that attrition is not responsible for the effects seen throughout the paper and that, more likely, the effects are due to direct effects rather than sample composition changes.

7. 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—much more than the effects of voluntary mobility. The closings also have long-term attainment

[29] I use attrition before 12th grade, because attrition after 12th grade is essentially the opposite of graduation. This is done by first estimating a propensity score of attrition using a variety of demographic and 9th grade (pre-closure) achievement variable and then weighting by that propensity score.

effects, decreasing both high school graduation rates and college attendance rates. 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 studied and may have detrimental effects of their own.

While these results are important, one should use caution before trying to generalize. I only estimate effects for one district—Milwaukee Public Schools. 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. It is possible that closures are particularly helpful for future cohorts of students who perhaps would have attended the closed school had it not closed.

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Table 1: Summary Statistics

	Obs	Mean	Std Dev	Min	Max
Demographics					
Female	94,834	0.502	0.500	0	1
Free/Reduced Lunch	94,834	0.752	0.432	0	1
English Language Learner	94,834	0.065	0.247	0	1
Disabilities	94,834	0.206	0.404	0	1
White	94,834	0.112	0.316	0	1
Black	94,834	0.628	0.483	0	1
Hispanic	94,834	0.187	0.390	0	1
Asian	94,834	0.051	0.221	0	1
Attend Local School	97,986	0.083	0.276	0	1
Academic Outcomes					
GPA	91,910	1.937	1.062	0	4
Attendance	95,719	0.806	0.212	0	1
Discipline Incidents	95,719	2.504	5.082	0	113
Discipline Suspensions	95,719	2.149	4.611	0	60
WKCE Math (10th Grade)	21,967	0.027	0.998	-3.143	5.111
WKCE Read (10th Grade)	21,892	0.020	1.001	-3.520	5.400
Graduation and College					
Graduates (9th Grade)	20,513	0.634	0.482	0	1
Graduates (12th Grade)	13,373	0.878	0.328	0	1
College Attendance (Graduates)	13,008	0.559	0.497	0	1
2 Year College	7,270	0.313	0.463	0	1
4 Year College	7,270	0.683	0.466	0	1
Mobility and Closures					
Has a closure (9th Grade)	26,060	0.080	0.271	0	1
Voluntary Mover (9th Grade)	26,060	0.450	0.497	0	1
Fraction Students from Closed Schools	97,986	0.019	0.047	0	0.75
Fraction Students New to School	97,986	0.440	0.172	0	1
Number of Students	26,315				
Number of Schools	89				

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	0.903	0.872	-0.031	0.849	0.806	-0.044
GPA	2.408	2.018	-0.390	1.979	1.690	-0.289
Discipline Incidents	2.826	4.279	1.454	3.400	4.597	1.197
Suspensions	1.259	2.072	0.813	1.652	2.351	0.700
Female	0.504	0.510	0.006	0.501	0.498	-0.003
Free/Reduced Lunch	0.768	0.855	0.087	0.752	0.842	0.090
English Language Learner	0.076	0.012	-0.064	0.072	0.011	-0.061
Disability	0.192	0.295	0.102	0.187	0.281	0.094
White	0.116	0.036	-0.081	0.113	0.034	-0.080
Black	0.593	0.875	0.281	0.604	0.869	0.265
Hispanic	0.208	0.040	-0.168	0.202	0.047	-0.154
Asian	0.054	0.028	-0.027	0.052	0.025	-0.027
Attend Local School	0.153	0.169	0.016	0.096	0.084	-0.012
WKCE Math	0.127	-0.314	-0.441	-	-	-
WKCE Reading	0.109	-0.346	-0.455	-	-	-
N	15,778	1,243		22,801	1,968	

Notes: "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	412.08	774.08	1081.58
Attendance Percent	76.37	77.54	81.31
Graduation Rate	63.16	68.16	77.16
10th Grade WKCE Math			
% Minimum	58.50	55.93	42.93
% Basic	17.20	20.33	21.36
% Proficient	12.92	16.18	26.97
% Advanced	0.43	1.00	3.45
10th Grade WKCE Reading			
% Minimum	42.59	38.14	27.15
% Basic	27.42	27.39	25.51
% Proficient	15.41	20.57	26.89
% Advanced	4.71	6.96	14.65
Charter School	0.46	0.26	0.17
MPS Data			
Attendance Percent	0.72	0.74	0.80
GPA	1.62	1.66	1.86
Discipline Incidents	3.09	2.98	2.67
10th Grade WKCE Math	-0.45	-0.30	-0.01
10th Grade WKCE Read	-0.42	-0.28	-0.01
Free/Reduced Lunch	0.83	0.80	0.75
Disability	0.26	0.23	0.21
English Language Learner	0.01	0.05	0.07
Local School	0.06	0.07	0.08

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.

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

	GPA (1)	Attendance Fraction (2)	Discipline Incidents (3)	Number of Suspensions (4)
Post-Closure	-0.127**	-0.024***	-0.522*	-0.371**
	(0.051)	(0.008)	(0.314)	(0.181)
Post-Voluntary Move	0.066***	-0.018***	-1.213***	-0.639***
	(0.021)	(0.005)	(0.127)	(0.058)
Fraction of Students from Closed Schools x (Indiv. From Closed School)	0.296**	-0.006	0.095	0.336
	(0.123)	(0.042)	(1.175)	(0.533)
Fraction of Students from Closed Schools x (Indiv. Not From Closed School)	0.633***	-0.033	-2.414	-2.034**
	(0.173)	(0.048)	(2.879)	(0.982)
Fraction of New (Non-Closure) Students	0.755***	0.062***	-4.431***	-1.549***
	(0.140)	(0.024)	(0.620)	(0.357)
N	92,695	96,217	96,227	96,227

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 clustered at the school level.

*** 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	-0.095	0.005	-0.091	-0.053***	-0.108	-0.003
	(0.061)	(0.045)	(0.074)	(0.015)	(0.497)	(0.255)
Post-Voluntary Move	-0.033	-0.062**	-0.069**	-0.039***	-0.401*	-0.085
	(0.021)	(0.025)	(0.032)	(0.006)	(0.223)	(0.088)
Fraction of Students from Closed Schools	-0.164	-0.369	0.586*	0.024	-1.925	-1.356
x (Indiv. From Closed School)	(0.282)	(0.244)	(0.337)	(0.065)	(2.368)	(1.410)
Fraction of Students from Closed Schools	-0.709**	-0.807**	0.724	-0.275**	-6.535**	-3.971***
x (Indiv. Not From Closed School)	(0.336)	(0.394)	(0.478)	(0.119)	(2.648)	(1.354)
Fraction of New (Non-Closure) Students	-0.121	-0.073	0.457***	0.014	-0.553	-0.071
	(0.085)	(0.071)	(0.174)	(0.021)	(0.625)	(0.303)
N	40,860	40,653	41,241	44,892	44,893	44,893

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 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	-0.063	0.013	-0.401	-0.080
	(0.093)	(0.012)	(0.436)	(0.254)
2 Years Before Closure	-0.025	0.010	0.102	0.242
	(0.077)	(0.010)	(0.373)	(0.330)
1 Year Before Closure	-	-	-	-
1 Year After Closure	-0.134**	-0.023***	-0.344	-0.283
	(0.063)	(0.008)	(0.378)	(0.263)
2 Years After Closure	-0.160**	-0.022**	-0.638*	-0.284
	(0.071)	(0.009)	(0.363)	(0.226)
3+ Years After Closure	-0.096	-0.007	-0.751	-0.462*
	(0.087)	(0.015)	(0.481)	(0.277)
N	92,695	96,217	96,227	96,227

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. 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 clustered at the school level.

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

Table 7: Effects of High School Closures on Educational Attainment

	Graduate On Time (1)	12th Grade Graduation (2)	College Attendance (3)	2-Year College Attendance (4)	4-Year College Attendance (5)
OLS					
Student Has Closure	-0.032*	-0.076***	-0.060***	-0.059***	-0.001
	(0.017)	(0.013)	(0.020)	(0.010)	(0.021)
N	14,356	9,911	8,949	8,949	8,949
P-Score Matching					
Student Has Closure	-0.004	-0.083***	-0.074**	-0.047*	-0.025
	(0.022)	(0.024)	(0.033)	(0.024)	(0.032)
N	13,606	9,329	8,258	8,258	8,258

Notes: All coefficients are estimated using students from the 2005-06 to 2008-09 freshman cohorts. Column (1) contain all freshmen, column (2) contains the subset that reach 12th grade, and columns (3)-(5) contain the subset that 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: Estimates of School Closure by Quality of Receiving School

Panel A: Difference-in-Differences Estimates of Achievement

Achievement Outcomes	GPA (1)	Attendance Percent (2)	Discipline Incidents (3)	Number of Suspensions (4)
Post-Closure	-0.214***	-0.023***	-0.570*	-0.357*
x (School has Higher WKCE Math)	(0.057)	(0.008)	(0.328)	(0.183)
Post-Closure	0.010	-0.027**	-0.447	-0.391*
x (School has Lower WKCE Math)	(0.056)	(0.011)	(0.438)	(0.232)

Panel B: OLS Estimates of Attainment

Attainment Outcomes	Graduate On Time (5)	12th Grade Graduation (6)	College Attendance (7)	2-Year College Attendance (8)	4-Year College Attendance (9)
Student Has Closure	-0.036*	-0.049***	-0.063**	-0.066***	0.002
x (School has Higher WKCE Math)	(0.020)	(0.015)	(0.025)	(0.016)	(0.029)
Student Has Closure	-0.025	-0.113***	-0.056*	-0.049**	-0.004
x (School has Lower WKCE Math)	(0.023)	(0.023)	(0.033)	(0.023)	-0.034

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 9: Estimates of School Closure Weighted by Probability of Attrition

Panel A: Difference-in-Differences Estimates of Achievement Weighted by Probability of Attrition

Achievement Outcomes	GPA	Attendance Percent	Discipline Incidents	Number of Suspensions
	(1)	(2)	(3)	(4)
Post-Closure	-0.101**	-0.015	-0.555	-0.444**
	(0.047)	(0.010)	(0.452)	(0.220)

Panel B: OLS Estimates of Attainment Weighted by Probability of Attrition

Attainment Outcomes	Graduate On Time	12th Grade Graduation	College Attendance	2-Year College Attendance	4-Year College Attendance
	(5)	(6)	(7)	(8)	(9)
Student Has Closure	-0.015	-0.093***	-0.097***	-0.047***	-0.043*
	(0.021)	(0.023)	(0.025)	(0.014)	(0.023)

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%

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

School Year	Number of Schools	Number of Schools 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

Figure 1: Event Study Analysis of School Closures on Achievement

Figure 1A: Event Study of School Closure on GPA

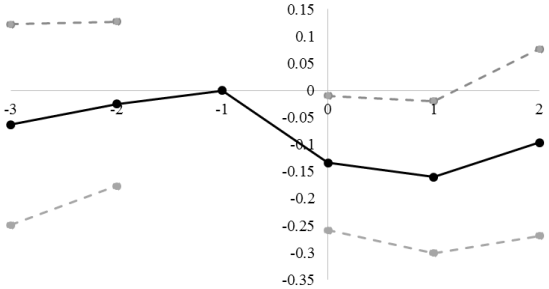

Figure 1B: Event Study of School Closure on Attendance

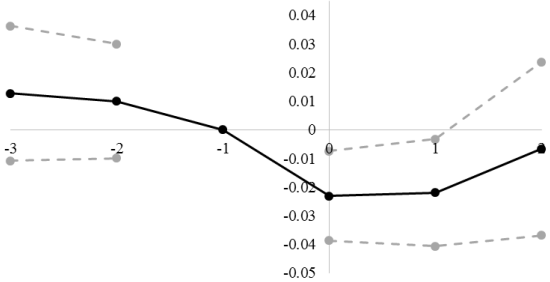

Figure 1C: Event Study of School Closure on Discipline Incidents

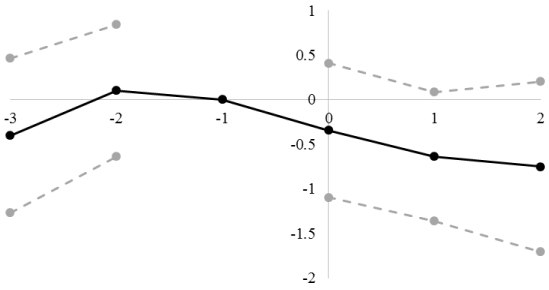

Figure 1D: Event Study of School Closures on Suspensions