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The effect of school closings on student achievement

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ABSTRACT

Many school districts across the country are shutting schools, but school closing policies remain a very controversial issue. The current study investigates the effects of school closing policies on student achievement by examining over 200 school closings in Michigan. Relative to the previous literature, the analysis uses a broader set of school closings to thoroughly investigate heterogeneity in treatment effects based on the performance level of the closed school. The results indicate that, on average, school closings in Michigan did no persistent harm to the achievement of displaced students. Moreover, students displaced from relatively low-performing schools experience achievement gains. The displacement of students and teachers creates modest negative spillover effects on the receiving schools, however. Hence, the closing of low-performing schools may generate some achievement gains for displaced students, but not without imposing spillover effects on a large number of students in receiving schools.

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1. Introduction

Over 1800 public schools were shut in the United States after the 2008–2009 academic year alone (Common Core of Data, 2011). School closings have become common nationwide, and urban centers such as Chicago, Detroit, Kansas City, New Orleans, Oakland, Philadelphia, and Pittsburgh have all recently closed schools. In addition, as policy discussions increasingly focus on high-stakes accountability, some policymakers have suggested shutting the lowest-performing schools and shifting students to higher-performing schools as a way to increase student achievement. Community leaders and teachers unions often vehemently oppose these school closings, however. In fact, during the recent teacher strike in Chicago, the president of the Chicago Teachers Union described the district's desire to shut schools with excess capacity as the “big elephant in the room” (Lah and Botelho, 2012). Given this controversy, understanding how school closings influence student achievement is essential for policymakers, because the extent to which districts should utilize closing policies depends crucially on the effect of closings on student achievement.

Theoretically, the effect of shutting schools on student achievement is ambiguous. On the one hand, school closings may cause harm to students, because the closings disrupt peer and teacher networks. This disruption may affect the displaced students who are forced to change schools as well as students at the receiving schools who experience an influx of new students and teachers. On the other hand, being displaced from low-performing schools may expose students to higher-quality peer groups and teachers, generating achievement gains. Hence, if students are systematically moved to higher-quality schools, the net effect of the displacement could very well be positive. Which of these effects dominates and under what circumstances is an open empirical question.

This paper provides evidence on the nature of these effects by examining school closings in Michigan. Michigan provides an excellent setting for examining school closings because a large number of schools have shut in the past decade. Using statewide student-level microdata to follow students after displacement, the study estimates the effects of school closings on both displaced students and students in nearby receiving schools. Because schools may be selected to close on the basis of their past test scores, the analysis examines the achievement trajectories of these schools prior to closure. By documenting the magnitude of the dip in test scores prior to closure, the analysis generates plausible bounds on the effect of closing schools. This bounding approach does not deliver point identified estimates, but generates policy relevant conclusions while relying on less restrictive assumptions than an approach that attempted to match closed schools to a control group of schools on the basis of past test scores. In addition, the current study examines a wide range of school closings and hence is better able than prior studies to estimate heterogeneous effects based on the performance level of the closed school. Identifying this heterogeneity is key for extrapolating these results to other settings. In particular, understanding whether districts should adopt policies of closing particularly low-performing schools will depend on the effects that closing low-performing schools generates on the achievement of both displaced students and students in the receiving schools.

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The results indicate that school closings in Michigan did no persistent harm to the achievement of displaced students. For reading, students experience no significant change in test scores at the time of displacement. For mathematics, students in closed schools are falling behind their peers in the district prior to closure, and this dip prior to displacement is not the result of formal school closing announcements. Student achievement in mathematics remains low in the first year in their new school, but improves markedly thereafter. In the second year following displacement, student test scores in mathematics are substantially higher than they were in the year prior to being displaced. This result suggests plausible bounds on the effect of school closings on student achievement. If the drop in test scores prior to closure is driven by a multiple period transitory shock, then the results indicate no long term effect of school closings on student achievement. If instead the drop prior to closing represents a declining trend in student achievement at the closed school, displacement has a positive impact on mathematics achievement for displaced students. In either case, school closings create modest negative spillover effects onto students in receiving schools, however, and these effects persist for multiple years. All of these results are robust to controlling for district-wide time trends and selective mobility of students out of schools prior to closure.

Intuitively, the effect of displacement varies based on the performance level of the closed school. In mathematics, students displaced from relatively low-performing schools experience gains in achievement compared to their prior performance at the closed school. In addition, the estimated effects on receiving schools vary with respect to the performance level of the closed schools. If students are displaced from relatively low-performing schools, the spillover effects are larger in magnitude. Further analysis shows positive effects in math from displacing students together to the same receiving school, but these effects are only temporary and fade after two or three years.

These results imply that districts forced to close schools due to changing demographics or financial problems do no persistent harm to the achievement of displaced students, and the spillover effects onto students in receiving schools are modest in magnitude. In addition, displaced students experience improvements in achievement if they are displaced from schools that are low-performing relative to nearby schools. Hence, school closings can be effective in raising the achievement of students in low-performing schools while imposing only modest negative spillover effects. However, a large scale policy to close low-performing schools will fail to improve average achievement district-wide because any gains from displaced students will be offset by achievement losses for students in receiving schools.

The paper proceeds as follows. Section 2 discusses the relevant literature, Section 3 describes the context and institutional details surrounding school closings in Michigan, and Section 4 outlines a conceptual model of how school closings can be expected to affect student achievement. Section 5 then discusses the data used in the analysis and Section 6 presents the empirical specification and results. Section 7 concludes, discussing policy implications of the results.

2. Literature review

The qualitative literature on school closings documents concern from both teachers and administrators that students displaced from closed schools would suffer from the displacement (Lipman and Person, 2007; Steiner, 2009; Kirshner et al., 2010). For example, Kirshner et al. (2010) investigate the closing of one large urban high school. In addition to documenting achievement losses, they report roughly 40% of students surveyed reported that they felt a sense of loss or that friendships and relationships were disrupted by the displacement. Whether this sort of disruption generates persistent achievement effects across a wide range of school closings is an empirical question.

The few quantitative studies to investigate school closing policies in particular districts have found mixed results, however.[1] Sacerdote (2012) examines the achievement of students forced to leave school due to Hurricane Katrina. His results indicate that students experience temporary sharp declines in test scores following displacement, but make up substantial ground thereafter and in many cases experience long-run achievement gains as a result of the displacement. The circumstances faced by Katrina evacuees are unique, however, and it is impossible to understand whether these results are driven by changes in family and residential circumstances due to the hurricane. In Chicago Public Schools, De la Torre and Gwynne (2009) evaluate school closings aimed at chronically low-performing schools, and find that the closings led to transitory drops in test scores.[2] The most comprehensive published study to date is Engberg et al. (2012), which investigates the closing of approximately 20 schools in an anonymous urban school district. The authors find that displaced students are harmed substantially, but these effects can be mitigated by sending displaced students to higher quality schools. Due to data limitations, however, they are unable to examine the achievement trajectory of students in closed schools prior to displacement. In addition, the policy investigated by Engberg et al. (2012) displaced 25% of the students in the school district in the same year. Because this large upheaval affected the majority of students in the district either directly or through spillover effects, it may be difficult to apply these results to other settings.

This disagreement about the effects of school closing policies is likely due to the fact that these results pertain to specific school closing policies, and not able to investigate broad-base and heterogeneous closing policies such as those investigated in the present analysis. By examining a larger variety of school closings, the current study seeks to add to this existing literature in three ways. First, the study examines a broader set of closings than these previous studies, and uses this large data set to investigate heterogeneity of school closing effects on the basis of school performance. Second, by using statewide micro-data, the analysis is able to account for students who leave the district after a school closing. This allows the analysis to be robust to non-random selection of students leaving the school district after a school closing. Last, the study pays particular attention to the role of teachers in school closing policies. In many school closings in Michigan, teachers are retained in the district after displacement. This generates additional spillover effects in a possibly distinct set of receiving schools.

The effect of shifting students from one school to another has also been studied in a variety of other contexts. For instance, a large literature documents achievement losses for students who change schools voluntarily or as part of a structural transition from elementary to middle school.[3] As well, the school choice literature uses random lottery admissions to examine the effect of being admitted to school choice programs on a variety of student outcomes, but students who apply to school choice programs are a select sample and hence different from students displaced by school closings.[4] The literatures on desegregation and peer effects also investigate the effect of shifting students from one school to another.[5] All of these policies differ from school closings in that they do not include the mobility of teachers that is typically generated

[1] A related literature that explores the effects of school turnarounds and reconstitutions (i.e., replacing school staff without shifting students to other schools) finds mixed results for student outcomes (Gill et al., 2007; Hess, 2003; Brady, 2003; Malen et al., 2002).

[2] Ongoing work by Barrow et al. (2012) investigates a similar set of school closings from Chicago and finds persistent drops in test scores for displaced students.

[3] Recent prominent papers in the voluntary student mobility literature include Hanushek et al. (2004), Xu et al. (2009), and Loeb and Valant (2011). See Rockoff and Lockwood (2010) for an examination of student mobility from elementary to middle school.

[4] Prominent examples of the school choice literature include Rouse (1998), Cullen et al. (2005), Abdulkadiroğlu et al. (2011) and Deming (2011).

[5] See Guryan (2004) or Reber (2010) for studies on the effects of desegregation policies and student outcomes. Imberman et al. (2012) and Angrist and Lang (2004) are prominent examples of studies that use exogenous movement of students to estimate the magnitude and structure of peer effects.

by a school closing. In addition, the policy environments are much different. For instance, the peer effects generated by Katrina evacuees in Houston, as studied by Imberman et al. (2012), are likely different than those generated by closing schools and shifting students to another school within the same school district.

3. School closings in Michigan

The current study examines the closing of 246 elementary and middle schools in Michigan between 2006 and 2009.[6] School closings in Michigan are driven almost exclusively by declining district enrollments. In addition to well-documented statewide population declines, an increase in school choice policies has led to further enrollment declines in some districts.[7] Fig. 1 displays the location of closed elementary and middle schools in Michigan between 2006 and 2009.[8] As can be seen, the Detroit Metropolitan Area had a large number of school closings over this time period. This includes not only many schools in the city of Detroit, but also schools in suburban areas. In addition, other urban centers such as Flint, Saginaw, and Grand Rapids have closed schools recently, and in fact the data contain multiple school closings from each of the five largest Combined Statistical Areas in Michigan. Hence, while a number of rural districts closed schools between 2006 and 2009, the analysis presented below is primarily representative of urban and suburban school closings.

While some districts make plans for school closures years in advance, the vast majority of districts do not decide on which school to close until the spring of the last year the school is open. The choice of which school to close is very complex, and the schools chosen for closure are often not the lowest-performing schools in the district. In addition to test scores, district officials examine factors such as school condition, enrollment, and location when making their decision. Nonetheless, because district officials take into account test scores when making their decision, closed schools are on average lower performing than neighboring schools.

After closure, students are assigned to a new school within the district. While parents can choose to move or have their children utilize a school choice program, the shutting of a school does not alter parents' choice of remaining schools. Displaced teachers also move within the district after a school closes. In fact, the fraction of teachers leaving the teaching profession is no larger after a closing than in a normal year.[9] While the majority of displaced students are usually transferred to the same nearby schools, displaced teachers can be shuffled throughout the district. Hence, schools that receive displaced teachers may be quite different from students in schools that receive displaced students, and both groups of schools may be affected by the closing.

4. Conceptual model

Consider the following stylized model of student achievement:

$$Y_{ist} = X_{it}\beta + M_{it}\alpha_{it} + \psi_{st} + \mu_i + e_{ist} \tag{1}$$

here, Y_{ist} represents the achievement of student i in school s at time t. X_{it} is a vector of student observable characteristics, ψ_{st} is a school quality component of student achievement, μ_i represents fixed student-level influences, and e_{ist} is an idiosyncratic error. Given that student mobility may affect student achievement for more than one year, M_{it} is a vector of indicators indicating that the student moved schools k years ago. In particular, $M_{it}\alpha_{it} = \sum_k \alpha_{it,k} m_{i,t-k}$ where $m_{i,t-k}$ is an indicator that the student moved schools in year $t-k$. Note that α_{it} varies both across students and within students over time. This allows for the fact that different students respond heterogeneously to moving schools, and the same student may respond differently to different moves. For example, students may experience less disruption when moving to new schools with many of their previous classmates or teachers.

For ease of exposition, assume that mobility has no effect on X_{it} and future values of m_{it}. This rules out scenarios where being displaced by a closing makes the student more likely to either move schools in the future or be placed in programs such as special education.[10] Letting T_{itk} be an indicator that the student was displaced due to a school closing k years ago, the causal effect of moving schools due to a school closing can be written as follows:

$$E[Y_{ist}|T_{itk}=1] - E\left[Y_{i,s',t}|T_{itk}=0\right] = \alpha_{it,k} + \left(E[\psi_{st}|T_{itk}=1] - E\left[\psi_{s',t}|T_{itk}=0\right]\right). \tag{2}$$

Similar to the model of student mobility discussed in Hanushek et al. (2004), this effect consists of two components. The first component represents the direct effect of changing schools on student achievement. Again, this effect may be heterogeneous among students depending on the circumstances surrounding the displacement. In addition to this direct effect, students will on average experience a change in school quality.

Note that the quality of the receiving school may change due to the influx of new peers and teachers. Hence, school closings may affect students in receiving schools as well as displaced students. In particular, consider the following decomposition of school quality:

$$\psi_{st} = \left(F^P_{st}\Pi^P + F^T_{st}\Pi^T\right) + SQ_{st} + u_{st}. \tag{3}$$

The first group of terms consists of F^P_{st} and F^T_{st}, which represent the fraction of students and teachers in a school who are new to the school, respectively. This captures that new students and teachers in the school may cause disruption to the learning environment. As with student mobility, disruption to the school environment may affect schools dynamically. Therefore, $F^P_{st}\Pi^P = \sum_j \pi^P_j f^P_{stj}$ and $F^T_{st}\Pi^T = \sum_j \pi^T_j f^T_{stj}$, where f^P_{stj} and f^T_{stj} represent the fraction of students and teachers at school s in year t displaced j years ago, respectively. SQ_{st} captures both school-level factors that are fixed in the school over time such as school facilities and administration, as well as aspects of school quality that may fluctuate within a school over time, such as the quality of the peer and teacher composition in the school. u_{st} is a school $*$ year level error term.

In this framework, the change in school quality following a displacement can be written as follows:

$$\begin{aligned}\psi_{st} - \psi_{s',t-k} = &\left(F^P_{st}\Pi^P - F^P_{s',t-k}\Pi^P\right) + \left(F^T_{st}\Pi^T - F^T_{s',t-k}\Pi^T\right) \\ &+ \left(SQ_{st} - SQ_{s',t-k}\right) + \left(u_{st} - u_{s',t-k}\right)\end{aligned} \tag{4}$$

The first two terms reflect that the receiving school experiences disruption due to the influx of new students and teachers. Hence, it is possible that students who might have been expected to move to a much better school as a result of displacement do not actually experience this improvement in school quality because the influx of teachers and students from the closed school reduced the quality of the receiving school. The last two terms will be important in the empirical analysis. In particular, consider two cases. On one hand, if student achievement improved after displacement because students were displaced to higher-quality schools, then $SQ_{st} > SQ_{s',t-k}$, which represents a causal

[6] This paper will adopt the convention of referring to academic years by the spring, i.e., the 2005–2006 academic year will be referred to as 2006.

[7] Toma et al. (2006) find that in Michigan around 80% of students who enroll in charter schools were previously enrolled in traditional public schools.

[8] These 246 closed schools include 18 charter schools.

[9] A small number of districts have placement policies based on teacher preferences, but the majority of displaced teachers are reassigned using standard district transfer policies that weigh school needs and administrator preferences in addition to the teacher's own stated preferences.

[10] The model can be readily extended to incorporate these effects, but their inclusion does not change the conclusions of the model.

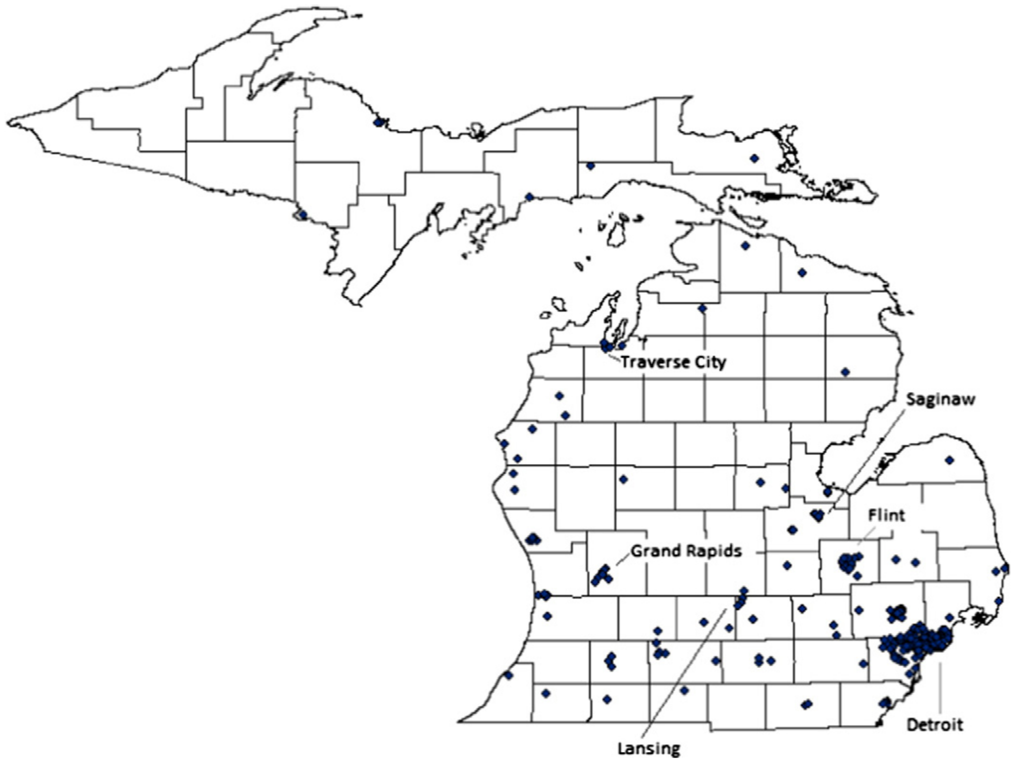

Fig. 1. Location of school closings 2006–2009.
Source: Author's calculations drawn from EEM data on school closings and student-level micro-data. For a description of the process for identifying school closings, refer to the Data Appendix.

effect of school closings on displaced students. On the other hand, if student achievement increased because $u_{st}>u_{s',t-k}$, this would not represent a causal increase in student achievement. For example, if schools were selected to be closed on the basis of their latest test scores, displaced students would have particularly low draws of $u_{s',t-k}$, leading $u_{st}-u_{s',t-k}$ to be positive. This issue is discussed in greater detail in Section 6.

Students in receiving schools also experience a change in school quality due to the disruption from new students and teachers and the change in peer and teacher quality. This effect may differ from that experienced by displaced students, however, because students at receiving schools do not experience changes in some aspects of school quality. For example, a school's curriculum is likely not changed by the influx of new students. Hence, the displacement of students would expose them to potentially better curriculum without changing the curriculum experienced by students who were already attending the receiving school. All of this discussion highlights that the effect of a school closing is context dependent. Hence, the analysis pays particular attention to heterogeneity in estimated effects by both the performance level of the closed school and the dispersion of students after displacement.

While being displaced by a school closing is a type of student mobility, it is important to note that the effect of moving schools due to a school closing is distinct from effects that have been estimated in other literatures on student mobility. In particular, these effects are likely to differ for at least three reasons.

First, the circumstances surrounding mobility may be different between displaced students and other movers. This will result in $\alpha_{it,k}$ being different on average for students displaced by closings compared to other forms of student mobility. For instance, students in closed schools often attend school post-displacement with many of their previous classmates. If the mobility effect is due to disruption in student peer networks as a result of the move, one might expect student achievement to be lower in the case of students who move by themselves when compared to students displaced by school closings. In addition, the discussion of the impending closure may create disruption in the school prior to closure. This disruption in student achievement would not occur prior to most other student moves and might alter the effect of the move on student achievement.

Next, as discussed in the voluntary mobility literature, different types of student moves will result in different changes in school quality. In the context of the current model, this implies that $\left(SQ_{st}-SQ_{s',t-k}\right)$ is different depending on the setting of the study. These differences in school quality may potentially be very different for school closings compared to other forms of student mobility because students are typically reassigned after closings. With other forms of student mobility, students are often explicitly making the decision to change schools, implying that they may be more likely to make their schooling decisions on the basis of school quality.

Last, the inflow of students following school closings is typically very large. Hence, F^P_{stj} and F^T_{stj} are greater in the context of school closings compared to other types of mobility. In addition, because the influx of new students and teachers into the receiving schools will often be much larger than influxes of other movers, school closings have the potential to fundamentally alter the quality of the receiving schools. In the context of the model, this implies that changes in SQ_{st} are potentially much larger for receiving schools after closings than typically would occur in the case of other forms of student mobility.

5. Data

This study uses student-level administrative data maintained by the Michigan Consortium for Educational Research (MCER). A detailed description of the data can be found in an online data appendix.[11] Briefly, the sample includes test scores of all students in grades 3–8 over the 2006–2010 academic years.[12] In total, this represents 1,252,101 students and 3,416,174 student ∗ year observations. Of these students, 39,205 were displaced by a school closing, with some students being displaced multiple times. In addition, 7.0% of the sample attends school in a district that closed a school the previous year, and may themselves be affected by closings due to spillover effects.

Student achievement scores are taken from the Michigan Educational Assessment Program (MEAP) exams, which are administered to students in grades 3–8 in early to mid-October. Therefore, displaced students usually take their last test in the closed school prior to the formal announcement of the school closing. The fall administration of the MEAP slightly changes the interpretation of the results. The Michigan Department of Education (MDE) designs the tests so that test scores in year t are the result of instruction in year $t-1$ (Michigan Department of Education, 2005). Nonetheless, it is possible that extensive MEAP preparation prior to taking the tests may affect MEAP scores. If test scores represent knowledge gained the current year, interventions should have an immediate impact. However, if test scores reflect knowledge gained the previous year, interventions should have a lagged effect on student achievement. The current study takes the approach of assuming that achievement in year t is the result of instruction in year t. This contrasts with the approach taken by Hoxby (2000), who assumes that achievement in year t is not affected by school inputs in year t. As will be seen later, treating achievement in year t as being the result of instruction in year $t-1$ only strengthens the results.

Table 1 presents descriptive statistics for the sample used in the analysis.[13] The table first displays statistics separately by the year in which the school closed, then displays statistics for the entire sample. As can be seen, the sample includes significant portions of minority and disadvantaged students. In particular, 42.9% of the sample is eligible for free or reduced-price lunch and 24.1% of the sample is either black or Hispanic. Comparing different cohorts of closed schools, schools that closed after the 2006 academic year have lower concentrations of African-Americans, lower concentrations of free or reduced-price lunch eligible students, and higher achievement than schools that closed after the 2007–2009 academic years. Nonetheless, when compared to the entire sample, the 2006 cohort tends is relatively more African-American, more free or reduced-price lunch eligible, and lower achieving. In addition, the 2007–2009 cohorts are relatively similar to each other and contain the majority of observations for displaced students. Hence, the results presented below are largely reflective of school closings in relatively disadvantaged, urban areas.

Table 2 presents descriptive statistics for students in closed schools in Michigan and compares them to all students in Michigan and students within their district. Compared to other schools in their district, closed schools enroll almost 100 fewer students. This is not an artifact of different grade configurations between open and closed schools, because closed schools have lower enrollment even comparing among schools with K-5 grade configurations. This evidence supports statements by district officials, who often cite declining enrollments as one of the key factors in deciding which schools to close. While students in closed schools are similar in terms of gender and Limited English Proficiency status compared to other students in the state, districts that close schools have much different demographics than districts that do not. Almost 50% of students displaced by school closings attend schools in urban areas. Compared to the average student in Michigan, these students are more likely to be African-American, participate in special education programs, and be economically disadvantaged as measured by eligibility for free or reduced-price lunch. These differences are largely due to differences between districts that close many schools and districts that do not. In terms of student achievement, students in closed schools tend to perform 0.4–0.5 standard deviations worse than the state average, but also a little over 0.1 standard deviations worse than students within their district. Hence, while the majority of poor performance by students in closed schools can be attributable to district-level differences, the fact that students in closed schools perform worse than peers in their own district supports anecdotal evidence from district officials that school performance is considered when making their decision of which school to close.

Table 3 displays statistics on the movement of students and teachers after closings. For the majority of school closings, non-trivial fractions of students either leave the school district or attend a charter school after

Table 1
Descriptives of students in closed schools.

Variable	Year of closure 2006	2007	2008	2009	Entire sample
Female	0.492	0.490	0.472	0.489	0.493
	[0.500]	[0.500]	[0.499]	[0.500]	[0.500]
White	0.518	0.353	0.375	0.305	0.716
	[0.500]	[0.478]	[0.484]	[0.461]	[0.451]
African-American	0.391	0.588	0.545	0.597	0.187
	[0.488]	[0.492]	[0.498]	[0.490]	[0.390]
Hispanic	0.060	0.032	0.048	0.067	0.053
	[0.237]	[0.176]	[0.213]	[0.250]	[0.224]
Special education	0.139	0.147	0.134	0.171	0.127
	[0.346]	[0.354]	[0.340]	[0.377]	[0.333]
Limited english proficient	0.032	0.029	0.037	0.043	0.039
	[0.175]	[0.167]	[0.189]	[0.204]	[0.193]
Free/reduced price lunch eligible	0.526	0.705	0.665	0.754	0.429
	[0.499]	[0.456]	[0.472]	[0.431]	[0.495]
School enrollment (K-5 schools only)	270.2	285.1	275.2	307.4	425.1
	[64.8]	[89.9]	[72.0]	[96.1]	[134.6]
School enrollment	614.9	379.6	354.6	368.3	538.5
	[560.5]	[184.5]	[158.3]	[182.3]	[233.9]
Elementary school[a]	0.198	0.346	0.218	0.326	0.272
	[0.398]	[0.476]	[0.413]	[0.469]	[0.445]
Rural school	0	0.029	0.072	0.043	0.244
	[–]	[0.168]	[0.259]	[0.202]	[0.429]
Urban school	0	0.669	0.540	0.713	0.247
	[–]	[0.471]	[0.498]	[0.452]	[0.431]
Mathematics score	−0.309	−0.551	−0.596	−0.578	0.006
	[1.025]	[1.002]	[0.908]	[0.970]	[0.998]
Reading score	−0.232	−0.470	−0.505	−0.531	0.003
	[1.088]	[1.070]	[1.053]	[1.053]	[0.999]
N	9789	10,867	5507	13,237	3,416,174

[a] An elementary school is defined as any school with highest grade less than or equal to 5.

Table 2
Descriptives of students in closed schools.

Variable	Students in closed schools	District mean	Entire sample
Female	0.488	0.497	0.493
African-American	0.536	0.496	0.187
Hispanic	0.053	0.079	0.053
Special education	0.151	0.137	0.127
Limited english proficient	0.036	0.066	0.039
Free/reduced price lunch eligible	0.671	0.651	0.429
School enrollment (K-5 schools only)	287.9	387.4	425.1
School enrollment	430.8	524.4	538.5
Elementary school[a]	0.285	0.282	0.272
Rural school	0.032	0.055	0.244
Urban school	0.500	0.662	0.247
Mathematics score	−0.506	−0.390	0.006
Reading score	−0.436	−0.318	0.003
N	40,141	364,794	3,416,174

[a] An elementary school is defined as any school with highest grade less than or equal to 5.

[11] Online material can be found on the author's website at same https://sites.google.com/site/quentinbrummet.

[12] While it is possible to identify school closings prior to 2006, the exam changed dramatically from 2005 to 2006 and hence scores before 2006 are not comparable to scores in 2006 and later. For this reason, only years 2006–2010 are considered in the analysis.

[13] A descriptive statistic table including standard deviations, minimums, and maximums for variables is available in Online Appendix Table D.1.

Table 3
Student and teacher movement after closings.

	N	Percentile					Mean
		10	25	50	75	90	
Fraction of students attending a new school district	246	0.015	0.031	0.056	0.104	0.169	0.093
Fraction of students attending a charter school	246	0.000	0.000	0.025	0.077	0.160	0.064
Median distance to new school for student	239	0.441	0.825	1.370	2.043	4.846	2.117
Fraction of students attending the modal receiving school	246	0.197	0.275	0.350	0.487	0.632	0.389
Fraction of teachers attending the modal receiving school	246	0.115	0.167	0.250	0.438	0.714	0.339

Each observation represents a single closed school. The modal school is defined separately for students and teachers as the receiving school that receives the largest number of students or teachers from closed schools, respectively.

displacement. This highlights one advantage to using state-wide administrative data to study school closings — it is much easier for parents to move out of district in response to school closings than to leave the Michigan public and charter school system.[14] In addition, the median student in that closed school attends a school less than 1.5 miles away from their previous school after being displaced. However, for some closings the median student attends school almost five miles away from their previous school after displacement.

As can be seen in Table 3, the fraction of students attending the modal receiving school after closure is often greater than the fraction of teachers attending the modal receiving school, underscoring the point that displaced teachers are typically more widely dispersed after closure than displaced students. In addition, there is substantial variation in how many students and teachers attend the modal receiving school. In some closings, many students are displaced to the same receiving school, creating potentially large influxes of students in particular receiving schools.[15] Closings where many students attend the same receiving school are often referred to as "consolidations," but there is no clear distinction between a closing and a consolidation. In particular, there is wide variation in the dispersion of students after displacement, and the degree of dispersion reflects district policies in addition to contextual factors such as school choice, parental resources, and public transportation.[16] Section 6.5 returns to this discussion, and estimates closing effects by the fraction of students who attend the same receiving school together.

6. Empirical analysis

Given the complex decision process for deciding which school to close, school closings are not likely to be randomly assigned conditional on student fixed effects and observable characteristics. Most importantly, district administrators often take student test scores into account when deciding what school to close, creating a pattern where student test scores in schools decline prior to closure. This dip could be due to either a systematic decline in student test scores prior to closure or a transitory decline in test scores, similar to the "Ashenfelter Dip" that has been observed in job training programs (Ashenfelter, 1978; Ashenfelter and Card, 1985). If the dip is transitory, it may lead conventional program evaluation techniques to overestimate the impact of school closings due to mean reversion in student test scores (Chay et al., 2005). Note that there could also be a causal effect of school closings on student achievement prior to closure. Closed schools are often in danger of being closed for years before they are eventually closed, which could lower student test scores through additional disruption in the schools.

Because of these concerns, it is important to consider the pattern of test scores prior to closure when investigating school closings. Consider the following model:

$$Y_{ist} = \sum_{k=-2}^{3} \delta_k T_{itk} + \sum_{j=1}^{3} 1\left[T_{itj}=0\right]\left(\pi_j^P f_{stj}^P + \pi_j^T f_{stj}^T\right) + X_{ist}\beta + \mu_i + \theta_{gdt} + \epsilon_{ist}. \quad (5)$$

The treatment specification for displaced students mirrors that found in the displaced worker literature and includes dummy variables indicating how many years the student is from displacement (Jacobson et al., 1993; Stevens, 1997). Specifically, for $k < 0$, T_{itk} is a dummy variable indicating that the student attends a school that will close in $|k|$ years.[17] If k is positive, T_{itk} takes a value of 1 if the student was displaced by a school closing k years ago.[18]

The variables f_{stj}^P and f_{stj}^T represent the fraction of students and teachers at school s in year t who were displaced j years ago, respectively. Both f_{stj}^P and f_{stj}^T are interacted with a variable indicating that the student was not displaced.[19] Hence, these measures are included in this specification to control for spillover effects on receiving schools, and are not interacted with the treatment specification for displaced students. Section 6.2 estimates whether influxes of displaced students at receiving schools disrupt learning for students at the receiving school as well as the displaced students themselves. Note also that these variables can also be defined at the grade level as opposed to the school level. School-level disruption measures are preferred for two reasons. First, they capture potentially important spillover effects across grade levels, which would bias the results if f_{stj}^P and f_{stj}^T were defined at the grade level. In addition, the fall administration of the MEAP means that multiple teachers may be responsible for student achievement in year t, implying that grade level f_{stj}^P and f_{stj}^T measure would miss spillover effects across grade levels.[20] Y_{ist} represents the achievement of student i in school s, year t. X_{ist} is a

[14] Appendix Table C.1makes use of this statewide data and documents that in the current setting dynamic mobility of displaced students out of school districts does not substantially affect the results.

[15] For instance, in some schools up to 74% of students were previously displaced by a school closing. This is unusual, however, as the median displaced student attends a school where roughly 20% of the student population was previously displaced.

[16] Note briefly that while there is wide variation in the types of school closings experienced by Michigan students, the setting is on average similar to previous studies. For example, Engberg et al. (2012) study a school closing policy where roughly 25% of the school district was displaced and the average non-displaced student attended a school where over 15% of his or her classmates were previously displaced. While it is difficult to find exact analogs to these figures in the current setting, the fact that the median displaced student attended a receiving school where 20% of the students were previously displaced suggests that student dispersion in the current setting is on average similar to that studied in Engberg et al. (2012).

[17] Some schools close using "phase-outs", where a school stops receiving new students and shuts once the final cohort of students has passed through the school. For the current analysis, only the final cohort of students would be coded as displaced. These students do not drive the results presented below, as in the current sample only 2.29% of displaced students are displaced by a "phase-out" and results are not sensitive to the inclusion of these students.

[18] For example, if a school closes after the 2008 academic year, students attending that school in 2007 have $T_{i,2007,-1} = 1$, $T_{i,2008,0} = 1$, and $T_{i,2009,1} = 1$.

[19] If a student moves into a school for a reason other than being displaced by a closing, they are counted as a student at the receiving school. The results are not sensitive to coding these students as "displaced" students as opposed to "students at the receiving school".

[20] Results using grade-level variation are qualitatively similar, and can be found in Online Appendix Table D.2.

vector of student controls containing free or reduced-price lunch eligibility, Limited English Proficiency status, and special education status.[21] All test scores are standardized within grade and year to have mean 0 and variance 1. μ_i and θ_{gdt} are student and grade ∗ district ∗ year fixed effects, respectively.

While school closings are potentially endogenous, the dynamic specification allows the researcher to identify separate effects of school closings based on what assumptions are made about the decline in test scores prior to displacement. If the drop in achievement prior to closure is caused by the closing itself or is transitory in nature, then the effect of school closings on student achievement k years after closure is δ_k. To the extent that drops in test scores represent a systematic decline in the quality of the closed schools, the effect of the school closure is at least as large as δ_k–δ_0. In particular, under the assumption that student achievement would have remained the same had the school not closed, the effect of displacement is exactly δ_k–δ_0. If the school was trending downwards, then δ_k–δ_0 is a lower bound for the effect of the displacement on student achievement.

As shown in Table 2, districts that closed many schools are much different than the average district in the state. The inclusion of grade ∗ district ∗ year fixed effects makes the analysis robust to any district-level time trends that may differ between districts that did or did not close schools. In addition, because a given test is administered to students in a particular year ∗ grade, this analysis compares students displaced by closure only to their peers within the district who took the same test.[22] These fixed effects make the estimation computationally demanding, however. As a result, the analysis uses a computational algorithm developed by Guimarães and Portugal (2010).[23] Standard errors are adjusted for clustering at the district level.[24]

Eq. (5) is similar to value-added models used to estimate teacher quality, which often condition on lagged student outcomes. However, recent simulation evidence by Guarino et al. (2011) shows that the decision of whether to condition on a lagged test score or student fixed effect should depend largely on the mechanism for assigning students to treatment. In the context of estimating teacher effects, estimators that condition on lagged test scores often perform well if students are tracked into classrooms on the basis of past test scores. However, the relevant assignment mechanism in the current study is how students are assigned to schools, which is likely to be based primarily on relatively time-invariant characteristics of students such as residential location. As such, a student fixed effects approach is preferred for the current study.

Given these concerns, the analysis is broken up into three parts. Section 6.1 estimates the average effect of school closings in Michigan on displaced students, Section 6.2 estimates potential spillover effects on receiving schools, and Section 6.3 examines possible explanations for the patterns observed in the data. Then, Section 6.4 examines heterogeneity based on the performance level of the closed school and Section 6.5 examines heterogeneity on the basis of dispersion of students after a closing.

[21] Student mobility history, average school demographics, and average rates of student mobility in the school are excluded as they are possible outcomes from school closings. The results are not sensitive to the inclusion of these variables.

[22] While not shown here, results are qualitatively similar using district ∗ year fixed effects as opposed to grade ∗ district ∗ year fixed effects. Note that the inclusion of district ∗ grade ∗ year fixed effects also that this makes the specifications similar to much of the school closing literature using district-level administrative data, which often includes either year or year*grade fixed effects.

[23] Briefly, this algorithm alternates between estimating the coefficients on the variables of interest and the fixed effects, holding one set of parameters fixed while estimating the other set.

[24] Adjusting for clustering at the district level is preferred since that is the level on which the decision to close a school is made. In practice, standard errors clustered at the district level are larger than those clustered at the school level, and hence the standard errors reported in the analysis can be viewed as conservative.

Table 4
Average effects of school closings on displaced students in Michigan.

	Math	Reading
2 years prior to closure	−0.004	−0.010
	[0.029]	[0.010]
1 year prior to closure	−0.041***	−0.013
	[0.014]	[0.011]
Year of closure	−0.061**	−0.026
	[0.030]	[0.017]
1 year after closure	−0.074**	−0.053
	[0.033]	[0.033]
2 years after closure	−0.016	−0.041
	[0.020]	[0.029]
3+ years after closure	−0.010	−0.033
	[0.016]	[0.021]
N	3,416,174	3,416,174

The unit of observation is the student ∗ year. Specifications include student and grade ∗ district ∗ year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, Limited English Proficiency status, and a treatment specification for spillover effects on students in receiving schools. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

6.1. Average effects of school closings in Michigan on displaced students

Table 4 contains estimates of the δ_k coefficients in Eq. (5), which summarize the average achievement trajectories of displaced students in Michigan. For mathematics, student test scores drop in the years prior to closure, stay low in the first year at their new school, and then improve in the years after closure. In particular, students perform 0.061 standard deviations worse during the last year the school is open compared to three years prior to closure. Student performance is even lower in the year after closure, and drops to 0.074 standard deviations below their performance three years prior.[25] Student achievement improves thereafter and, two years after closure, is similar to levels two years prior to closure and significantly better than in the last year in the closed school.[26] Note again that because the MEAP is given during the fall, much of the poor student performance in the first year after displacement could be the result of knowledge that was gained the year before. Hence, the estimated coefficient for one year after displacement may overstate any potential negative effects from the displacement.

As discussed previously, this analysis provides plausible bounds for the effect of school closings on the achievement of displaced students. If the drop in student test scores prior to closure is transitory in nature, school closings have short-run negative effects on displaced students, but no long-run effects. Hence, at the very least the results imply that school closings in Michigan had no sustained negative impacts on displaced students. To the extent that drops in mathematics scores prior to displacement represent a declining trend not caused by the school closing itself, the effect of the closing is positive, and over the long run student achievement in mathematics improved as a result of the displacement. Section 6.3 will return to this and present evidence about the nature of the dip in student performance prior to displacement.

For reading scores, the pattern is less clear. On the whole, the estimated achievement trajectories are similar for mathematics and reading. Student achievement drops prior to displacement and in the first year at the new school, but improves moderately thereafter. There are some important differences between reading and mathematics,

[25] Given that there are five years of data and six treatment indicators, it is clear that different cohorts of displaced students identify different subsets of the δ_k coefficients. If the composition of school closings differs substantially from year to year, then the dynamic pattern of the pooled results will not accurately reflect the true effect of school closings. Appendix A displays the results of specifications like those shown in Section 6.1, but where treatment is defined separately for each cohort. The results are qualitatively similar.

[26] The p-value for a Wald test testing that mathematics achievement two years after displacement is the same as mathematics achievement the year prior to displacement is 0.0628.

however. In particular, the dip in test scores prior to displacement is not significant, and the results are not estimated with enough precision to rule out that student achievement does not change after displacement.[27] Hence, while these estimates are imprecise, the results indicate the potential for only modest effects of displacement on student achievement in reading.

Both Sacerdote (2012) and De la Torre and Gwynne (2009) similarly find fadeout in displacement effects, but these patterns contrast with those presented in Engberg et al. (2012), who find sustained detrimental effects from displacement. There are multiple possible explanations for this difference in results. For one, these studies only analyze data from single school districts and therefore are unable to account for dynamic mobility of students out of districts after closure. If displaced students are more likely to move out of a school district when their achievement is trending upwards, estimates will be biased toward estimating overly negative effects of school closings. Appendix C documents that dynamic mobility of displaced students out of school districts does not affect the results in the current setting, however, and hence dynamic mobility is an unlikely explanation for differences in results. In addition, it is possible that displaced students experienced different changes in school quality between the two settings. The only other study to attempt to estimate heterogeneity in closing effects on the basis of the performance level of the closed school is Engberg et al. (2012), who use a measure of school quality developed by the school district, which is difficult to extrapolate to other settings. This point is returned to in Section 6.4, which estimates heterogeneity in school closing effects by performance level of the closed school.[28] Also, Engberg et al. (2012) examine a policy that displaced 25% of students in the school district in a single year. Hence, the disruption studied in this district may not be representative of school closing policies where a smaller fraction of students in the district were displaced. Whether these explanations account for the differences in results is a question for future research.

6.2. Spillover effects on receiving schools

While the results presented above control for potential spillover effects on students in receiving schools, they do not investigate these effects directly. The influx of new students may dramatically change the schooling environment and adversely affect learning for students in receiving schools. In addition, these influxes may disrupt student learning in the entire school, and students displaced to receiving schools with large influxes of displaced students may experience different achievement trajectories than students displaced to receiving schools with smaller influxes of displaced students. To examine these issues, Table 5 displays results from specifications as described by Eq. (5) with one modification: the fraction of displaced students in the receiving school is interacted with the treatment specification for displaced students.[29] Therefore, this specification separately estimates potential effects of disruption at the receiving school on both displaced students and students at the receiving schools.

The results show that both displaced students and students previously attending the receiving schools are negatively affected by the influx of new students. To interpret the size of these coefficients, consider that the standard deviation of the fraction of displaced students in a receiving school is roughly 0.035, so the −0.218 coefficient for mathematics represents a 0.008 standard deviation decline in student achievement for a one standard deviation increase in the fraction of students in the school who were just displaced by a school closure. Likewise, the −0.280 coefficient on reading can be interpreted as a 0.010 standard deviation drop in student achievement for each standard deviation increase in the fraction of displaced students in the school. These results could potentially be biased if students were sent to schools that were trending up or down prior to receiving the displaced students. While not shown here, leads of the f^P_{st1} and f^T_{st1} variables are close to zero, providing support for the assumption that students were not dynamically sorted into receiving schools.[30]

These figures are of the same magnitude as those reported in Hanushek et al. (2004) for the fraction of students who voluntarily move into the school. While this estimate is very small, it is important to note that, unlike voluntary moves studied in Hanushek et al. (2004), school closings affect concentrated geographic areas, and most receiving schools are likely to experience a much larger than one standard deviation increase in the fraction of displaced students when nearby schools close. In fact, the median displaced student attends a school in which roughly 20% of the student body was just displaced the previous year. In this case, student achievement at the receiving school declines by roughly 0.044 standard deviations in math and 0.056 standard deviations in reading as a result of the influx of new students.[31]

Receiving schools are also affected by an influx of displaced teachers. Similar to previous results, both displaced students and students at the receiving school are affected similarly by the disruption. In particular,

Table 5
Effects of school closings on receiving schools.

	Math	Reading
Displaced students		
Fraction of displaced students	−0.246*	−0.266**
	[0.132]	[0.113]
Fraction of displaced students (lagged)	−0.113	−0.208**
	[0.103]	[0.083]
Fraction of displaced students (twice lagged)	−0.200*	−0.064
	[0.111]	[0.068]
Fraction of displaced teachers	−0.071***	−0.035
	[0.019]	[0.030]
Fraction of displaced teachers (lagged)	−0.145***	−0.101***
	[0.042]	[0.034]
Fraction of displaced teachers (twice lagged)	−0.133***	0.025
	[0.033]	[0.059]
Students at receiving schools		
Fraction of displaced students	−0.218*	−0.280**
	[0.112]	[0.133]
Fraction of displaced students (lagged)	−0.189***	−0.249
	[0.073]	[0.153]
Fraction of displaced students (twice lagged)	−0.184**	−0.257*
	[0.092]	[0.145]
Fraction of displaced teachers	0.003	−0.032*
	[0.031]	[0.019]
Fraction of displaced teachers (lagged)	−0.082***	−0.134***
	[0.029]	[0.032]
Fraction of displaced teachers (twice lagged)	−0.046	−0.114**
	[0.032]	[0.047]
N	3,416,174	3,416,174

The unit of observation is the student ∗ year. Specifications include student and grade ∗ district ∗ year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, Limited English Proficiency status, and a treatment specification for displaced students. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

[27] The *p*-value for a Wald test testing that reading achievement two years after displacement is the same as reading achievement the year prior to displacement is 0.4354.

[28] In addition, the model estimated by Engberg et al. (2012) does not include student fixed effects, but controls instead for student's baseline test scores. As explained in Todd and Wolpin (2003), if the baseline scores measure student achievement with error, the estimated model under-adjusts for student fixed effects. The resulting omitted-variables bias is likely to generate overly negative estimates of displacement effects.

[29] Refer to Online Appendix Table D.4 for full estimates of this specification, where the main treatment specification for displaced students is estimated for those students attending receiving schools with mean levels of fraction of displaced students and teachers in their receiving school after displacement.

[30] Online Appendix Table D.3 contains the estimates of regressions including leads of the treatment variables.

[31] One might expect that larger schools have more resources to shift around, and hence are better able to accommodate the same percentage change in new students compared to smaller schools. If this were the case, then there would be heterogeneity in spillover effects with regards to school size. This does not appear to be the case, however, as the spillover effects do not vary with the size of the receiving school.

the fraction of displaced teachers in a receiving school tends to have a negligible negative effect in the first year, and is significantly larger in magnitude two or more years afterwards for both mathematics and reading. This pattern could be explained by the fall administration of the MEAP, as instruction in year t may not have its full impact until year $t+1$. The implied negative impact is very small, however. The median school receiving displaced teachers has 16.7% of its teaching force composed of displaced teachers.[32] This implies that for students in these receiving schools, the drop in mathematics test scores due to the new teachers would be small in first year and rise to 0.014 the year after. The effect on reading scores is similar. In the first year there is a negligible 0.005 drop in test scores, but the year after student achievement is 0.022 lower than before the influx of new teachers. While these estimates are smaller in magnitude than those presented previously for the fraction of displaced students entering a school, they are not statistically different.

6.3. Possible explanations for changes in student achievement

The interpretation of the results may change substantially depending on the explanation of the dip in mathematics test scores prior to displacement. One possible explanation is that announcements of school closings caused a drop in student and teacher morale which drove the decrease in test scores prior to closure. This is unlikely though, because the vast majority of closings in Michigan were announced during the spring of the last year the school was open, after students had taken the MEAP exams.[33] In particular, these closings contain over 90% of all students who were displaced. This implies that the drop in student achievement prior to closure is not driven by disruption resulting from the formal announcement that the building would be closed.[34] This does not rule out the possibility that the discussion of impending closure caused disruption in the learning environment prior to the formal announcement of the closure, but it is unlikely that the formal announcements of the school closings are driving the decline in test scores prior to closure.

Another possible explanation is that students were selectively moving out of schools prior to closure. Because the treatment specification in Eq. (5) defines all students attending schools prior to closure as treated, students switching into or out of schools prior to closure help to identify the model, implying that dynamic selection of these students may bias the results. In addition, the analysis above ignores other student mobility patterns that may be correlated with school closings. To address both these concerns, Table 6 displays results based on specifications such as that shown in Eq. (5), with a separate treatment specification estimated both for students who move schools voluntarily and for students who move out of schools prior to the closing. The estimated mathematics trajectory for displaced students is very similar to that shown in Table 4, implying that the drop in test scores prior to displacement is not driven by selective mobility out of schools prior to closing. For reading, the drop in student achievement appears to be slightly larger than in Table 4. Nonetheless, students still recover substantially in the two to three years after displacement and the results are not statistically different from those presented previously. In addition, achievement trajectories for displaced students and voluntary movers are statistically different in both mathematics and reading. This underscores the fact that moving schools voluntarily is a different treatment from being displaced by a school closing. Note also that voluntary movers experience a decline in test scores in the last year in their old school, suggesting that voluntary moves are endogenous to student achievement.

Table 6
School closings and voluntary student mobility.

	Displaced students	Voluntary movers from closed schools	Other voluntary movers
Panel A: mathematics achievement			
2 years prior to move	−0.005	–	0.002
	[0.050]	–	[0.004]
1 year prior to move	−0.046*	0.057***	−0.002
	[0.026]	[0.020]	[0.005]
Year of move	−0.052	−0.033*	−0.027**
	[0.035]	[0.019]	[0.011]
1 year after move	−0.075*	−0.005	−0.036***
	[0.044]	[0.016]	[0.005]
2 years after move	−0.022	0.036**	−0.022***
	[0.028]	[0.017]	[0.005]
3+ years after move	−0.013	0.058**	−0.015***
	[0.021]	[0.025]	[0.004]
Panel B: reading achievement			
2 years prior to move	−0.012	–	−0.002
	[0.035]	–	[0.004]
1 year prior to move	−0.024	0.024*	−0.003
	[0.021]	[0.013]	[0.004]
Year of move	−0.020	−0.013	−0.026***
	[0.027]	[0.017]	[0.007]
1 year after move	−0.072*	0.004	−0.019***
	[0.042]	[0.020]	[0.005]
2 years after move	−0.060	−0.010	−0.009**
	[0.039]	[0.023]	[0.004]
3+ years after move	−0.036	−0.012	−0.012***
	[0.029]	[0.021]	[0.005]

N = 3,416,174. All coefficients for a given dependent variable are estimated in the same regression. Specifications include student and grade ∗ district ∗ year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, Limited English Proficiency status, and a treatment specification for spillover effects on students in receiving schools. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

Given these results, it is unlikely that either formal announcements of closings or selective mobility of students out of closed schools drove the drop in mathematics scores prior to displacement. This still leaves open the possibility that the drop was the result of a transitory shock in student test scores, and schools were selected to be closed on the basis of these negative shocks. However, the fact that the shock is present for multiple periods rules out a story that the school simply had one bad year and students rebounded afterwards due to simple mean reversion.[35] One explanation that cannot be ruled out is that discussion of the impending closure harmed closed schools relative to other schools in the district. While this is possible, a potentially more likely explanation is that district administrators shut schools that were systematically losing ground prior to closure. If this latter explanation is true, the increase in mathematics scores after displacement is not simply a statistical artifact but a causal increase in student test scores. In either case, the substantive conclusions for reading scores are unchanged. There is no detectable dip in achievement prior to displacement and student achievement does not change significantly after displacement. These results are unchanged accounting for selective mobility of students out of schools prior to closure and do not appear to be driven by formal announcements of school closings.

One potential explanation for the increase in student achievement after displacement is that school closings occurred as part of a district-wide plan to upgrade facilities, as previous research has found that upgrading facilities can produce moderate student achievement gains (Cellini et al., 2010). Given the current fiscal environment in Michigan,[36]

[32] The median displaced student attends a school where 5.3% of the teachers were displaced one year prior.

[33] Data on date of announcement of school closings were obtained from internet searches of newspaper articles and personal communication with district officials. There is substantial missing data on when school closings were announced, however, corresponding to 19.5% of displaced students.

[34] Online Appendix Table D.5 contains results of specifications estimated just on the set of school closings not announced in advance.

[35] In addition, if the fall MEAP test does measure knowledge gained in prior periods as it was designed, this implies that the shock would have needed to be present for three years in a row to explain the results.

[36] Another concern is that the fiscal environment in Michigan had direct implications for student achievement during school closing policies. Online Appendix Table D.6 documents that results are qualitatively similar when restricting to high-unemployment school districts, however, which suggests that the economic well-being of a community does not directly influence the effects of school closing policies.

however, very few of the school closings currently studied are a result of these sorts of plans. In fact, only a little over ten percent of the displaced students considered in the analysis attended school in a district that was upgrading facilities, and results are qualitatively similar when limiting the analysis to just those districts without such plans.[37] One might also think that by closing schools, districts are able to devote more expenditures toward students as opposed to building maintenance. However, results available from the author suggest that the distribution of district-level per-pupil expenditures do not change significantly when districts close buildings.[38]

One might also worry that the increase in test scores after closure was driven entirely by selective attrition of displaced students from the Michigan public school system. While the analysis is robust to attrition based on time-constant factors, dynamic attrition of displaced students out of the Michigan public and charter school system would bias the results. Only 2.25% of students displaced by closure leave Michigan public schooling compared to 2.11% of all other students, however.[39] As previously documented in Table 3, it is much more likely for students to either leave the school district or attend a charter school after displacement. Hence, while it is possible for students to leave the state or attend private schools after closure, these figures suggest that bias resulting from dynamic selection of students moving out of Michigan or to private schools is likely not a first-order concern for the current analysis.[40]

The next section will examine another possible explanation for the increase in mathematics achievement after displacement. In particular, it will examine the role of school performance in the effect of school closings on student achievement and whether increases in school performance can explain the estimated gains in mathematics after displacement.

6.4. Heterogeneity by performance of the closed school

As discussed in Section 4, the effect of school closings on student achievement can be expected to vary based on the performance of closed schools relative to nearby receiving schools. Hence, estimating heterogeneity in the effects of school closings with respect to the performance of the closed school is essential for evaluating the effects of a potential school closing policy. It is important to note that there are two possible effects of interest. One effect of interest is the effect of moving from a low- to high-performing school. This is the question that is answered if students are randomly assigned to receiving schools after displacement. However, a question of greater policy interest is the effect of closing a low-performing school, taking into account that districts cannot forcibly assign students to receiving schools after displacement.[41] Because no school closing policy can force students to attend their assigned school after displacement, the effect of shutting a low-performing school will include the location and schooling choices that are made by parents after the closing. Hence this study investigates heterogeneity in effects based on the difference in performance between the closed school and nearby schools.

The current study uses the average of 4th and 7th grade proficiency rates from 2000 to 2005 as a measure of school performance.[42] This contrasts with Engberg et al. (2012), who use a value-added index generated by the anonymous school district to measure the quality of the closed school. Proficiency rates are preferred for the current study because value-added measures attempt to partial out aspects of school performance that are out of the school's control, including peer effects.[43] The effect of shutting a low-performing school will depend on all components of school performance, however. Average school proficiency measures capture peer inputs in addition to school and teacher quality. This is important because the effect of shutting schools will depend on these changes in peer composition.[44]

As with the main results presented in Section 6.1, the specification examines the achievement trajectory of displaced students prior to closure. In particular, it interacts the treatment variables from Eq. (5) with the difference in school performance between the closed school and nearby schools that remained open:

$$\begin{aligned} Y_{it} = & \sum_{k=-2}^{3} \delta_k T_{itk} + \sum_{j=1}^{3} 1\left[T_{itj}=0\right]\left(\pi_{1j}^{P} f_{stj}^{P} + \pi_{1j}^{T} f_{stj}^{T}\right) \\ & + \sum_{k=-2}^{3} \gamma_k T_{itk}\Delta_{itk} + \sum_{j=1}^{3} 1\left[T_{itj}=0\right](\pi_{2j}^{P} f_{stj}^{P}\overline{\Delta}_{itj}^{P} + \pi_{2j}^{T} f_{stj}^{T}\overline{\Delta}_{itj}^{T}) \\ & + X_{ist}\beta + \mu_i + \theta_{dgt} + \epsilon_{ist} \end{aligned} \quad (6)$$

where Δ_{itk} is the difference between the performance of the closed school and average performance of all schools within three miles of the closed school for students who were displaced k years ago. Some students are displaced multiple times in the sample period and may have $\Delta_{it,k} \neq \Delta_{it,k+1}$, because the two closed schools from which they were displaced had different relative performance levels. Most students are displaced only once, however, and in these cases $\Delta_{itk} = \Delta_i$, which is a time-invariant measure of the relative performance of the school from which the student was displaced. Note that because Δ_{itk} does not vary within a given cohort of displaced students, the identification of heterogeneity in effects based on the performance of the closed school uses only variation across school closings and not within-closing variation in which school a student attends after displacement. The resulting estimates therefore reflect long-run locational choices of parents that are arguably exogenous conditional on student fixed effects, and are not biased by parental decisions on where to send their children after displacement. $\overline{\Delta}_{stj}^{P}$ and $\overline{\Delta}_{stj}^{T}$ represent school-level averages of Δ_{itf} for students and teachers in a receiving school displaced j years ago, respectively.[45] These spillover effects are estimated only for students who were not themselves displaced j years ago (i.e., $T_{ij} = 0$).

In the current sample, the average displaced student attends a school that is 0.66 standard deviations below the state average in

[37] The estimates of these regressions are available in Online Appendix Table D.7. Districts are classified as upgrading facilities if they have obtained a qualified bond to renovate or construct a new elementary or middle school over the previous five years. These data is publicly available from the Michigan Department of Treasury and can be found at same https://treas-secure.state.mi.us/apps/findschoolbondelectinfo.asp.

[38] Expenditure information is publicly available from Bulletin 1014, which is published by the Center for Educational Performance and Information and can be found at same http://www.michigan.gov/mde/0,1607,7-140-21514-,00.html.

[39] The corresponding figure for students in receiving schools is 2.70%.

[40] Data from the 2010 Private School Universe Survey indicate that on the order of 6–7% of Michigan students attend private schools. This is roughly half the size of the fraction of students who utilize school choice programs such as charter schools or inter-district choice.

[41] Engberg et al. (2012) instrument for the quality of school that a student attends post-displacement with the quality of the school to which the student was assigned to attend, which estimates the effect of school quality on student achievement for students who attend their assigned school after displacement.

[42] To ensure comparability across years, these measures are normalized within year to have mean zero and standard deviation one. As a frame of reference, in the current sample one standard deviation in proficiency rates corresponds to roughly a 0.4–0.5 standard deviation difference in student test scores.

[43] Depending on the specification of the value-added model, school quality may be defined to include peer quality or teacher quality in addition to fixed school-specific components. Nonetheless, as the estimates in the current study are estimated using within-student variation, any differences in the results when using value-added compared to average performance measures would more likely be due to differences in the measurement of peer and teacher quality than differences in student ability.

[44] While average proficiency rates are preferred for the current study, it is possible to construct out-of-sample value-added measures for the sample of schools used in the analysis. Results from specifications as shown in Eq. (6) using these value-added measures are available in Appendix Table B.2. The results are qualitatively similar.

[45] Instead of interacting Δ_{itk} with the treatment specification, one could interact the performance level of the closed school and the performance level of nearby schools separately with the treatment. This produces qualitatively similar results to what is presented in Table 7, and hence the current specification is preferred for ease of exposition.

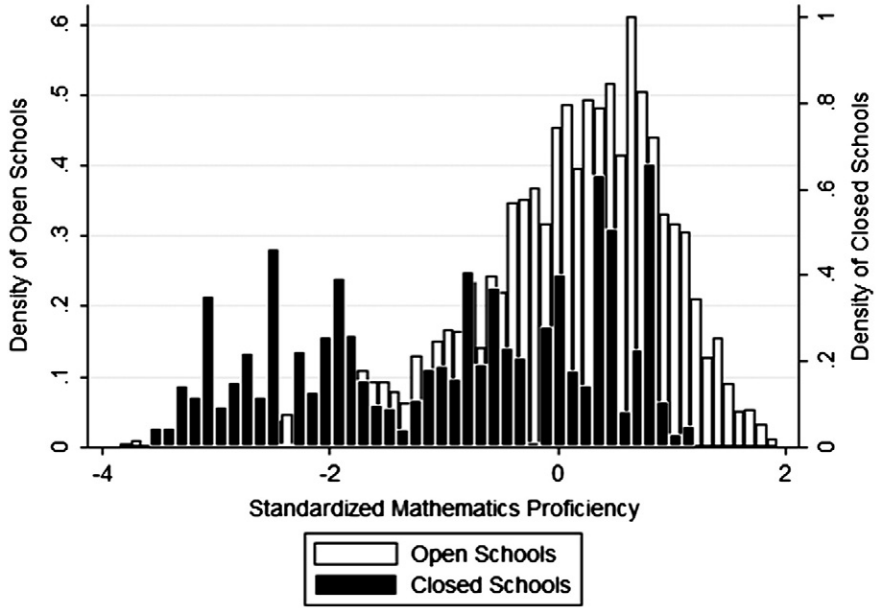

Fig. 2. Distribution of school performance statewide.
Source: Author's calculations from publicly-available test score proficiency rates released by the Center for Educational Performance and Information. Standardized mathematics proficiency refers to the average of 4th and 7th grade mathematics proficiency rates from 2000 to 2005, standardized within grade and year to have a mean of zero and standard deviation of one.

terms of school performance the year prior to displacement, and 0.30 standard deviations below the average of schools within three miles. There is substantial heterogeneity in performance of the closed school, however. Fig. 2 shows the distribution of standardized math proficiency statewide, and plots separate densities for both closed and open schools. The density for schools that were closed is shaded black and the density for schools that remained open is shaded white. Examining Fig. 2, it is clear that the average closed school was below average for the state, but there is substantial variation in the performance level of closed schools and in some cases closed schools were above the state average.

Table 7 displays three achievement trajectories (i.e., $\hat{\delta}_k + \hat{\gamma}_k \Delta_{itk}$) based on estimates of Eq. (6).[46] The first column displays the achievement trajectory for students who attended a closed school that was 0.5 standard deviations worse in terms of school performance than nearby schools. The middle column displays the same trajectory for students who attended a closed school of the same quality as nearby schools, and the final column contains students who attended a closed school that was 0.5 standard deviations better than nearby schools. The results show that students who attended poor-performing closed schools experience sharp increases in test scores after displacement, and two or more years after displacement are performing better than they ever did in the closed school. Students displaced from schools of the same quality as nearby schools experience a drop in achievement prior to closure and into their first year after displacement, but recover and perform no differently two or three years after displacement than they did two or three years prior to displacement. Students displaced from higher-performing schools are hurt by displacement, though, and never recover in their new school. Hence, while shutting low-performing schools generates achievement gains, shutting high-performing schools does persistent harm to student achievement.[47]

Table 7
Displaced student achievement trajectories by change in school performance.

	Closed school .5 s.d. below nearby schools ($\Delta_{itk} = -0.5$)	Closed school Same as nearby schools ($\Delta_{itk} = 0$)	Closed school .5 s.d. above nearby schools ($\Delta_{itk} = 0.5$)
Mathematics			
2 years prior to closure	−0.018	0.004	0.027
	[0.023]	[0.028]	[0.036]
1 year prior to closure	−0.048***	−0.035***	−0.019
	[0.013]	[0.013]	[0.017]
Year of closure	−0.073**	−0.049	−0.023
	[0.032]	[0.034]	[0.036]
1 year after closure	−0.078**	−0.077**	−0.071**
	[0.038]	[0.035]	[0.035]
2 years after closure	0.010	−0.033	−0.073
	[0.056]	[0.023]	[0.048]
3 years after closure	0.043**	−0.020	−0.081***
	[0.018]	[0.017]	[0.021]
N	3,257,564		
Reading			
2 years prior to closure	−0.021	−0.009	0.004
	[0.019]	[0.011]	[0.032]
1 year prior to closure	−0.036***	−0.009	0.019
	[0.013]	[0.015]	[0.021]
Year of closure	−0.053***	−0.019	0.015
	[0.016]	[0.011]	[0.016]
1 year after closure	−0.068**	−0.057*	−0.047
	[0.032]	[0.030]	[0.032]
2 years after closure	0.036	−0.054**	−0.144
	[0.087]	[0.027]	[0.115]
3 years after closure	−0.045	−0.047**	−0.048
	[0.039]	[0.021]	[0.034]
N	3,292,314		

For a given value of Δ_{itk} as defined in Section 6.4, trajectories are calculated as the (main effect)+Δ_{itk}(interaction), where main effect and interaction coefficient estimates may be found in Appendix Table B.1. Specifications include student and grade * district * year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, Limited English Proficiency status, and a treatment specification for spillover effects on students in receiving schools. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

[46] The parameter estimates of Eq. (6) can be found in Appendix Table B.1.

[47] Since the policy idea of shutting down failing schools is often targeted at schools in urban settings, it is important to examine the effects of shutting down low-performing schools in these areas. Online Appendix Table D.8 contains the results of specifications such as shown in Table 7, limiting the sample to only Detroit Public Schools.

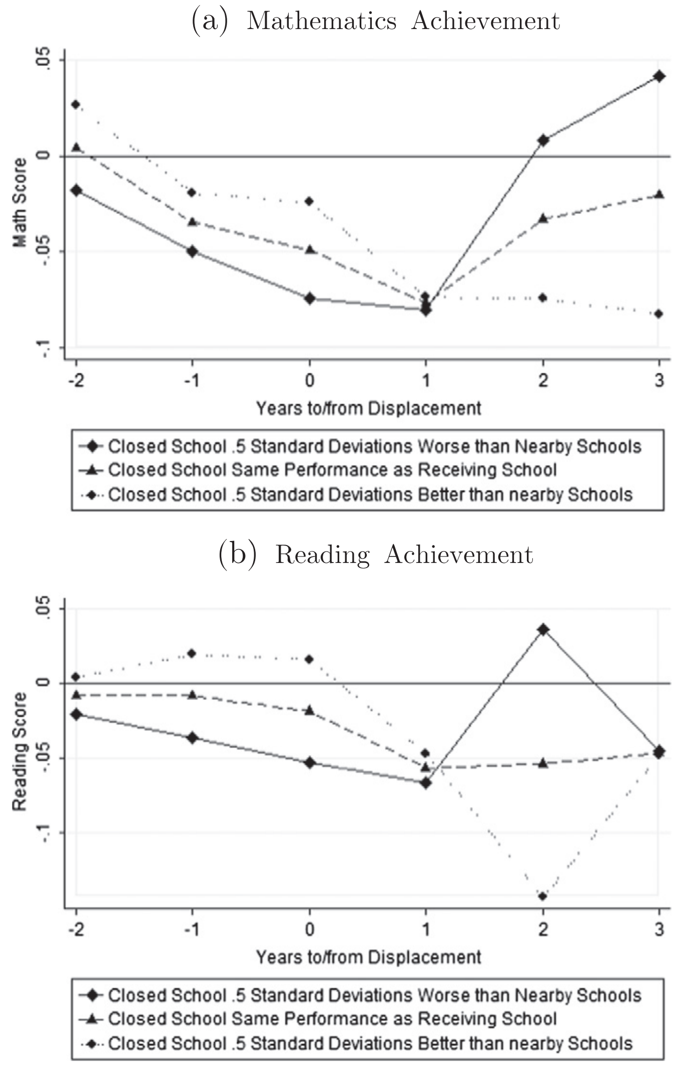

Fig. 3. Achievement trajectory of displaced students by performance of closed school.
Source: Author's calculations from student-level micro-data. Achievement trajectories calculated as linear combinations of coefficients shown in Appendix Table B.1. Standard errors of trajectories may be found in Table 7.

For reading, the pattern is again less clear. While students are trending similarly prior to displacement, there is no clear pattern in achievement after displacement. This can be explained by a story that mathematics scores are more heavily influenced by factors within school control, while reading scores are more heavily influenced by other factors such as parental involvement. Both mathematics and reading trajectories are plotted out in Fig. 3. Prior to displacement students in these three groups have similar achievement trajectories. The year after displacement, students displaced from low-performing schools experience slight increases in mathematics scores relative to their peers. Two or more years after displacement, these students continue to improve and are performing significantly better in mathematics than they ever did in the closed school. For reading, there is no distinct pattern between the three lines, again suggesting that reading scores may be less influenced by school-level factors.

The relative performance of the closed school affects not only the magnitude of the effects on displaced students, but also the magnitude of the effects on students in receiving schools. Fig. 4 plots out the differential impacts of closed school performance for schools that contain 20% displaced students or 20% displaced teachers.[48] Unsurprisingly, spillover effects are larger in magnitude if displaced students come from relatively low-performing schools. For displaced teachers, heterogeneous effects for mathematics are significant at the .10 level in the first year after teachers are displaced, but become imprecise thereafter. These results are consistent with a story that spillover effects from displaced students are due to negative peer effects from displaced students, while spillover effects from displaced teachers are due to disruption as the school accommodates the new teachers.[49] Another possible

[48] Specifically, Fig. 4 plots out $0.2 \cdot \left(\hat{\pi}^P_{1j} + \hat{\pi}^P_{2j}\overline{\Delta}^P_{stj}\right)$ and $0.2 \cdot \left(\hat{\pi}^T_{1j} + \hat{p}i^T_{2j}\overline{\Delta}^T_{stj}\right)$ for various values of $\overline{\Delta}^P_{stj}$ and $\overline{\Delta}^T_{stj}$.

[49] An alternative explanation for the negative spillover effects on receiving schools is that receiving schools were near capacity and had difficulty accommodating the new students who entered the school. As documented in Online Appendix Table D.9, the results are qualitatively similar when controlling for capacity of the school, using the maximum enrollment in the school since 1990 as a crude proxy for capacity.

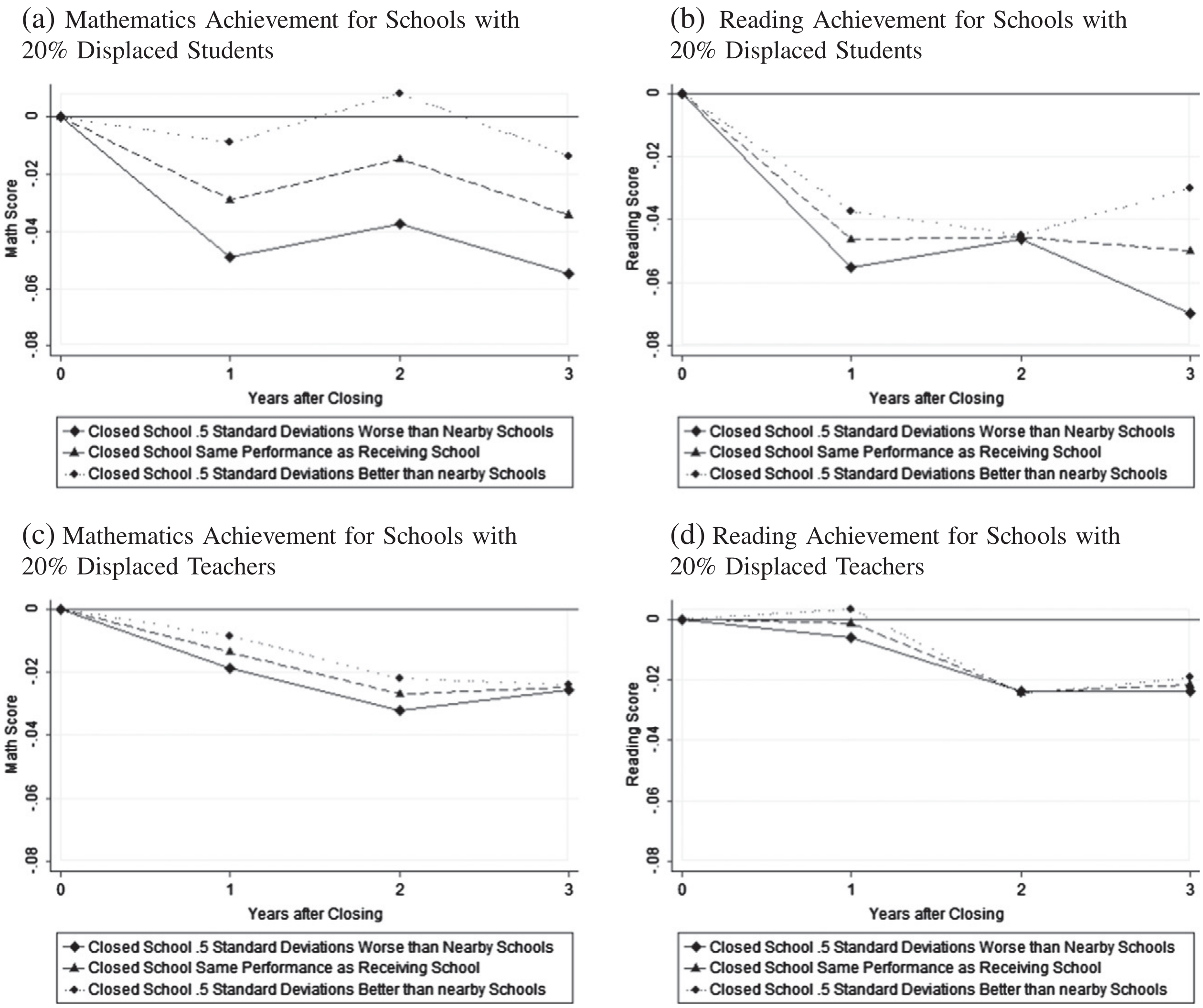

Fig. 4. Performance trajectory at receiving schools by performance of closed school.
Source: Author's calculations from student-level micro-data. Achievement trajectories calculated as linear combinations of coefficients shown in Appendix Table B.1.

explanation is that the disruption is due to teachers who are not accustomed to dealing with new students. If this were the case, one might expect the lowest grade at the new school to not experience as much disruption, because the teachers in these grades are accustomed to accommodating new students. While not shown here, spillover effects do not vary between the lowest grade and older grades in receiving schools.[50]

6.5. Heterogeneity by dispersion of students after displacement

School closing policies may also differ by the degree to which displaced students move to the same school after a closing. In particular, some policies shift large groups of students to a particular nearby school, while other policies may disperse students across multiple schools. To investigate this possibility, this section estimates specifications such as that shown in Eq. (6) with an additional interaction of the treatment specification with a measure of the dispersion of students after displacement:

$$\begin{aligned} Y_{it} = & \sum_{k=-2}^{3} \delta_k T_{itk} + \sum_{j=1}^{3} 1\left[T_{itj}=0\right]\left(\pi_{1j}^{P} f_{stj}^{P} + \pi_{1j}^{T} f_{stj}^{T}\right) \\ & + \sum_{k=-2}^{3} \gamma_{1k} T_{itk} \Delta_{itk} + \sum_{j=1}^{3} 1\left[T_{itj}=0\right]\left(\pi_{2j}^{P} f_{stj}^{P} \overline{\Delta}_{stj}^{P} + \pi_{2j}^{T} f_{stj}^{T} \overline{\Delta}_{stj}^{T}\right) \\ & + \sum_{k=-2}^{3} \gamma_{2k} T_{itk} D_{itk} + \sum_{j=1}^{3} 1\left[T_{itj}=0\right]\left(\pi_{3j}^{P} f_{stj}^{P} \overline{D}_{stj}^{P} + \pi_{3j}^{T} f_{stj}^{T} \overline{D}_{stj}^{T}\right) \\ & + X_{ist}\beta + \mu_i + \theta_{dgt} + \epsilon_{ist}. \end{aligned} \quad (7)$$

Here, the treatment specification for displaced students is interacted with D_{itk}, the fraction of students from a particular school closing that attended the modal receiving school. This measure is defined to be the

[50] These results may be found in Online Appendix Table D.10.

same for every student displaced from a particular school. Hence, similar to Section 6.4, the estimates presented here are identified off of between-closing variation and do not utilize variation in where parents choose to send their student after a particular closing. Note also that different levels of dispersion of students after displacement may be correlated with the performance level of the closed school. Hence, the estimates presented below reflect the achievement trajectories of respective groups of students conditional on being displaced from a similarly low-performing school.[51] Heterogeneity in spillover effects on students in receiving schools is also estimated by interacting $\overline{D}_{stj}^{P}$ and $\overline{D}_{j}^{stT}$ with the f_{stj}^{P} and f_{stj}^{T} variables, where $\overline{D}_{stj}^{P}$ and $\overline{D}_{stj}^{T}$ are the averages of the dispersion measure D for students and teachers in a receiving school who were displaced j years ago, respectively. Similar to Section 6.4, these measures are defined only for students who were not displaced j years ago.

Table 8 shows estimates from these specifications. Panel A presents results for mathematics scores of displaced students, while panel B shows results for displaced student reading scores. Note that spillover effects are not shown here, but the results indicate no significant differences in spillover effects across closings by the fraction of displaced students attending the modal receiving school.[52] Different achievement trajectories are shown for students displaced from schools where 25, 35, or 50% of students attending the modal receiving school.[53] The results for mathematics indicate that as more displaced students attend the modal receiving school, there is less disruption the year prior to and the year following displacement. However, this gap disappears two to three years after displacement and students are performing at similar levels despite being displaced to multiple receiving school. This may suggest that students displaced to many receiving schools experience more short-run disruption due to loss in peer networks, but the results should be interpreted cautiously as they are somewhat imprecise. For reading, there is some evidence of potential heterogeneous effects across different groups of students, but the results are very imprecise and not statistically significant from one another. Hence, taken as a whole these results suggest the potential for short run benefits from keeping groups of students together after a school closing, but are not able to statistically differentiate whether these differences matter in the long run.

Given the estimates presented above, it is unlikely a policy to systematically close low-performing schools would be able to generate substantial achievement gains without imposing widespread spillover effects on receiving schools. For instance, consider a hypothetical policy that shut a school that was 0.5 standard deviations below the average for nearby schools. A simple back-of-the-envelope calculation based on the above estimates would suggest that student achievement three years after displacement will be 0.118 standard deviations higher on average than it was during their last year in the closed school.[54] However, spillover effects may mitigate many of these gains. For instance, suppose that the closed school was half the size of the nearby schools and the displaced students were distributed evenly over four different schools, resulting in a relatively small 11% of the receiving school population being new to the school. Given the estimates presented above, students at the receiving school would have their achievement lowered by around 0.02 standard deviations. If displaced teachers were to be retained within the district, this would be even larger. In addition, the spillover effects will be larger due to the influx of low-performing peers. In this example, this implies that the spillover effects will be roughly .01 larger in magnitude due to the low-performing peers. Hence, even in this optimistic scenario, displaced students would only experience a positive gain in achievement of 0.098 compared to a 0.03 decline for students in receiving schools. While this loss is smaller in magnitude than the gain in achievement for displaced students, students in receiving schools constitute a much larger segment of the district population. Keeping students together after displacement may yield modest short-run improvements, but the results show no significant impact in the long run. Hence, average achievement district-wide will not improve.

This calculation does not rule out all justifications for school closing policies. First, the results from Section 6.1 suggest that even when there are negative effects from closings, they tend to be modest. Hence, if there are large financial gains from shutting down schools then closings may be an effective cost-saving tool for school district administrators to undertake. As well, the above calculation focuses on average district-wide student achievement. It may be that districts wish to maximize the minimum level achievement in the district, in which case school closing policies may be justified because they have the potential to substantially raise achievement for the subset of students in very low-performing schools. Nonetheless, this analysis does point to the limitations of targeted school closing policies as a large-scale policy tool to improve student achievement. Any policy will have to balance

Table 8
Displaced student achievement trajectories by fraction of students attending modal receiving school.

	Fraction of students attending modal receiving school		
	25%	35%	50%
Panel A: mathematics			
2 years prior to closure	−0.022	−0.024	−0.027
	[0.047]	[0.054]	[0.065]
1 year prior to closure	−0.031	−0.024	−0.012
	[0.026]	[0.038]	[0.056]
Year of closure	−0.102**	−0.075*	−0.033
	[0.046]	[0.041]	[0.035]
1 year after closure	−0.017	0.006	0.040
	[0.032]	[0.030]	[0.029]
2 years after closure	−0.001	0.008	0.022
	[0.015]	[0.020]	[0.032]
3 years after closure	0.030	0.044	0.065
	[0.023]	[0.031]	[0.045]
N	3,292,314		
Panel B: reading			
2 years prior to closure	−0.027	−0.034	−0.045
	[0.022]	[0.030]	[0.044]
1 year prior to closure	0.041	0.067	0.107
	[0.045]	[0.060]	[0.082]
Year of closure	−0.059*	−0.045**	−0.025**
	[0.035]	[0.021]	[0.012]
1 year after closure	0.004	0.026	0.058
	[0.029]	[0.031]	[0.038]
2 years after closure	0.003	0.019	0.042
	[0.040]	[0.048]	[0.060]
3 years after closure	−0.002	0.013	0.035
	[0.042]	[0.051]	[0.065]
N	3,292,314		

Reported trajectories calculated as linear combinations of estimated coefficients from Eq. (7) in a method similar to that used in Table 7. x% of previous classmates is defined as x% of students from a closed school attending the modal receiving school after displacement. Specifications include student and grade ∗ district ∗ year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, Limited English Proficiency status, and a treatment specification for spillover effects on students in receiving schools. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

[51] Being displaced from a relatively low-performing school may also have different results depending on whether or not a student continues to attend school with his or her previously low-performing peers. Further interacting the treatment specifications for relative performance and fraction of students attending the modal receiving school yields estimates that are too imprecise to be meaningful, however, and hence are not presented here.

[52] These results may be found in Online Appendix Table D.11.

[53] These numbers were chosen because they roughly correspond to the 25th, 50th, and 75th percentiles across school closings of the fraction of students attending the modal receiving school. See Table 3 for the full distribution of this variable.

[54] This calculation reflects the figures presented in the middle column of Table 8, but the conclusions are not sensitive to changing how many displaced students are kept together after a closing.

the costs of achievement losses at receiving schools against any potential achievement gains for displaced students.

7. Conclusion

Given the prevalence of school closings, understanding the effects of shutting schools on student achievement is crucial for policymakers. The results show no significant change in reading scores in the two to three years before and after displacement. For mathematics, students in closed schools are falling behind their counterparts in the district prior to displacement. After closure, students continue to perform at a low level in the first year in a new school but improve significantly within two to three years after displacement. In both reading and mathematics, the influx of new students and teachers negatively impacts students in receiving schools, but the losses tend to be modest. The results vary based on the performance of the closed school. If the closed school was low-performing relative to nearby schools, displaced students perform relatively better after displacement and students in receiving schools perform relatively worse.

These results have important implications for policymakers. First, the fact that school closings in Michigan did no persistent harm to student achievement suggests that school closings may be an effective policy tool for districts that need to cut costs. In addition, because students displaced from low-performing schools experience increases in test scores after closure, there is the potential for increases in achievement for displaced students by shutting low-performing schools. This increase in achievement comes at the expense of additional disruption due to the influx of previously low-performing new students in receiving schools, however. Moreover, these spillover effects are even larger if teachers from the low-performing school are reassigned within district. Hence, while closing low-performing schools may generate some achievement gains for displaced students, it is unlikely that these policies can improve average student achievement district-wide.

There are other potential consequences associated with school closing policies that are outside the scope of the current study. In addition to the impact on the achievement of students immediately affected by the policy, school closings will have longer-run impacts that are outside the context of the current analysis. In particular, school closings have lasting effects on quality of schools that future cohorts of students attend. Closings may also fundamentally alter the way in which students are distributed throughout the district, changing the structure of peer effects. In addition, closings create potentially important effects on teacher labor markets. When schools close, teachers are shuffled throughout the district, often on the basis of seniority. This reshuffling changes both teacher-school matches and the structure of teacher peer effects, both of which have the potential to significantly affect student achievement (Jackson and Bruegmann, 2009; Jackson, 2013). Hence, the welfare effects of closing schools may go beyond immediate achievement effects on the displaced students and receiving schools. While these issues are still very much unresolved, understanding the immediate impacts on student achievement due to school closings provides policymakers with valuable information to consider when weighing the costs and benefits of shutting down schools.

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Appendix A. Baseline analysis separate by closing cohort

Table A.1 displays the results of specifications like those shown in Table 4, but where treatment is defined separately for each cohort of displaced students. All coefficients shown are relative to student achievement in 2006.

Table A.1
Effects of school closings by closing cohort.

	Year of displacement			
	2006	2007	2008	2009
Panel A: mathematics achievement				
2 years prior to closure				−0.008
				[0.029]
1 year prior to closure			0.012	−0.046***
			[0.037]	[0.018]
Year of closure		−0.033***	0.004	−0.084***
		[0.011]	[0.021]	[0.032]
1 year after closure	−0.035	−0.021	−0.013	−0.095**
	[0.029]	[0.015]	[0.038]	[0.043]
2 years after closure	−0.017	0.038*	0.037	
	[0.029]	[0.020]	[0.038]	
3 years after closure	−0.023	0.045**		
	[0.026]	[0.018]		
Panel B: reading achievement				
2 years prior to closure				−0.012
				[0.008]
1 year prior to closure			−0.010	−0.013
			[0.027]	[0.020]
Year of closure		−0.027	−0.029	−0.031
		[0.019]	[0.023]	[0.020]
1 year after closure	−0.036	−0.023	−0.007	−0.073
	[0.028]	[0.015]	[0.021]	[0.047]
2 years after Closure	−0.062*	−0.008	0.003	
	[0.033]	[0.024]	[0.019]	
3 years after closure	−0.082**	0.018		
	[0.038]	[0.016]		
Number of displaced students	9942	11,063	5613	13,523
N	3,416,174	3,416,174	3,416,174	3,416,174

The treatment specification is set to 0 for all displaced students except for students displaced following the given academic year. Specifications include student and grade*district*year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, Limited English Proficiency status, and a treatment specification for spillover effects on students in receiving schools. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

Appendix B. Results with interactions for school performance differential

The following table displays estimates of the specification shown in Eq. (6).

The following table displays estimates of the specification shown in Eq. (6), with value-added measures used in place of average school proficiency rates. Value-added measures are constructed by taking the Ordinary Least Squares estimate of ψ from the regression equation $Y_{ist} = X_{ist}\beta + \psi_s + u_{ist}$ using data from years 2001–2005, where X_{ist} includes controls for race, gender, Limited English Proficiency, migrant student status, free or reduced-price lunch status, and lags of both math and reading test scores. These measures are then standardized to have mean zero, standard deviation one.

Table B.1
School closings and school performance.

	Math		Reading	
	Main effect	Interaction	Main effect	Interaction
Displaced students				
2 years prior to closure	0.004	0.044*	−0.009	0.025
	[0.028]	[0.023]	[0.011]	[0.048]
1 year prior to closure	−0.035***	0.030**	−0.009	0.055***
	[0.013]	[0.014]	[0.015]	[0.021]
Year of closure	−0.049	0.050***	−0.019*	0.069***
	[0.034]	[0.009]	[0.011]	[0.024]
1 year after closure	−0.077**	0.007	−0.057*	0.020
	[0.035]	[0.016]	[0.030]	[0.023]
2 years after closure	−0.033	−0.083	−0.054**	−0.179
	[0.022]	[0.094]	[0.027]	[0.197]
3 years after closure	−0.020	−0.123***	−0.047**	−0.003
	[0.017]	[0.018]	[0.021]	[0.059]
Students at receiving schools				
Fraction of displaced students	−0.145	0.201***	−0.232*	0.090***
	[0.131]	[0.067]	[0.140]	[0.034]
Fraction of displaced students (lagged)	−0.073	0.230	−0.228	0.006
	[0.063]	[0.158]	[0.148]	[0.094]
Fraction of displaced students (twice lagged)	−0.171*	0.207	−0.250	0.199
	[0.092]	[0.309]	[0.175]	[0.244]
Fraction of displaced teachers	−0.069***	0.051*	−0.006	0.047**
	[0.020]	[0.030]	[0.022]	[0.023]
Fraction of displaced teachers (lagged)	−0.135***	0.050	−0.120***	−0.004
	[0.063]	[0.061]	[0.045]	[0.022]
Fraction of displaced teachers (twice lagged)	−0.124***	0.007	−0.108**	0.024
	[0.028]	[0.052]	[0.048]	[0.023]
N	3,257,564		3,292,314	

All coefficients for a given dependent variable are estimated in the same regression. Specifications include student and grade ⁎ district ⁎ year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, and Limited English Proficiency status. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

Table B.2
School closings and school performance using value-added measures.

	Math		Reading	
	Main effect	Interaction	Main effect	Interaction
Displaced students				
2 years prior to closure	0.003	0.049***	−0.007	0.021
	[0.027]	[0.016]	[0.011]	[0.014]
1 year prior to closure	−0.035***	0.030**	−0.005	0.034**
	[0.012]	[0.012]	[0.018]	[0.016]
Year of closure	−0.049*	0.052***	−0.010	0.044*
	[0.028]	[0.009]	[0.018]	[0.025]
1 year after closure	−0.077**	0.009	−0.051*	0.022
	[0.036]	[0.015]	[0.031]	[0.021]
2 years after closure	−0.031	0.054	−0.052*	−0.032
	[0.022]	[0.147]	[0.029]	[0.150]
3 years after closure	−0.014	−0.091***	−0.049**	−0.034
	[0.018]	[0.020]	[0.024]	[0.042]
Students at receiving schools				
Fraction of displaced students	−0.153	0.198***	−0.187*	0.112***
	[0.103]	[0.062]	[0.110]	[0.038]
Fraction of displaced students (lagged)	−0.121**	0.208	−0.215*	0.106*
	[0.056]	[0.135]	[0.123]	[0.064]
Fraction of displaced students (twice lagged)	−0.216***	0.372**	−0.243**	0.309*
	[0.081]	[0.160]	[0.123]	[0.174]
Fraction of displaced teachers	−0.094***	−0.002	−0.019	0.012
	[0.023]	[0.039]	[0.023]	[0.023]
Fraction of displaced teachers (lagged)	−0.130*	0.044	−0.113**	−0.031
	[0.067]	[0.034]	[0.044]	[0.026]
Fraction of displaced teachers (twice lagged)	−0.109***	−0.006	−0.101**	−0.005
	[0.034]	[0.043]	[0.044]	[0.025]
N	3,257,564		3,292,314	

All coefficients for a given dependent variable are estimated in the same regression. Specifications include student and grade ⁎ district ⁎ year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, and Limited English Proficiency status. Standard errors are adjusted for clustering at the district level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

Appendix C. Dynamic mobility and school closings

The following tables contain estimates for Detroit Public Schools (DPS). The first column corresponds to the estimates presented in Online Appendix Table D.8, while the second column runs the same specification, but drops any observation from outside DPS. This corresponds to the specification a researcher would run if he or she only had access to data for one large urban school district. For simplification, estimated trajectories are shown for a group of displaced students where the closed school was performing at 0.5 standard deviations below nearby schools.

The results show that in DPS, dynamic mobility of students out of the district after a closing does not substantially affect the estimates. These differences in coefficients between the two columns are extremely small and are not statistically significant. These results support the theory that selective mobility of students out of districts after a closing is largely accounted for using student fixed effects, and, at least in the current setting, dynamic mobility of students out of school districts is not a concern.

Table C.1
School closings and dynamic mobility of students after displacement in Detroit public schools.

	(1)	(2)
	Keeping Movers	Removing Movers
Panel A: mathematics		
2 years prior to closure	−0.040	−0.040
	[0.036]	[0.036]
1 year prior to closure	−0.046	−0.047
	[0.031]	[0.031]
Year of closure	−0.116***	−0.117***
	[0.039]	[0.039]
1 year after closure	−0.148***	−0.148***
	[0.036]	[0.037]
2 years after closure	−0.060	−0.057
	[0.048]	[0.049]
3 years after closure	−0.025	−0.016
	[0.055]	[0.056]
Reading		
2 years prior to closure	−0.017	−0.017
	[0.035]	[0.035]
1 year prior to closure	−0.006	−0.008
	[0.027]	[0.028]
Year of closure	−0.053	−0.055
	[0.036]	[0.036]
1 year after closure	−0.116***	−0.116***
	[0.033]	[0.033]
2 years after closure	−0.099**	−0.107**
	[0.043]	[0.044]
3 years after closure	−0.100*	−0.077
	[0.051]	[0.052]
N	3,257,564	3,292,314

Specifications include student and grade ⁎ year fixed effects as well as controls for free or reduced-price lunch eligibility, special education status, Limited English Proficiency status, and a treatment specification for spillover effects on students in receiving schools. Standard errors are adjusted for clustering at the school level. *** indicates significance at the 0.01 level, ** at the 0.05 level, and * at the 0.1 level.

Appendix D. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jpubeco.2014.06.010.

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