How Does Grade Configuration Impact Student Achievement? Evaluating the Effectiveness of K-8 Schools.

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Abstract: Recently, there has been a move towards K-8 schools as opposed to stand-alone middle schools. In this paper, we examine the effect of enrollment in a stand-alone middle school relative to a K-8 school using a longitudinal data from an anonymous district using an alternative identification strategy from the previous literature and find results inconsistent with previous research. Overall, our results from the geographic boundary approach are less supportive of a K-8 policy and raises questions of the robustness of the previous conclusions.

Keywords: Grade Configuration, School Closure, Geographic Quasi-experiment

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I. Introduction

Research suggests that middle school students are vulnerable to risks of poor long-term outcomes given the physical, emotional, and intellectual changes they experience during these years (Juvonen et al., 2004). Therefore, the middle school years are critical in establishing a strong academic foundation for later life success. Yet U.S. middle schools have been called the "Bermuda Triangle" of education as students often become disengaged resulting in stagnant student learning and discipline problems and could ultimately lead to an increased likelihood of students dropping out during high school (Juvonen et al., 2004). While there have been a number of reforms implemented for students across the grade spectrum more generally—including increased expenditures, improved accountability, school choice, teacher incentives, and class size reduction—few reforms have specifically focused on middle school years.

One possible middle school reform is modifying the grade configuration of schools. During the 19th century, the vast majority of public elementary schools served grades K through 8 (Schwerdt and West, 2013). However, due to increasing enrollments, school districts started shifting toward junior high schools in which stand-alone schools served students in grade 7-8 or 7-9. Later, during the 1960s, reformers argued that students in grade 6 should join students in grade 7-8 to form stand-alone middle schools. These middle schools were viewed as way to ease the transition from primary to high schools as middle schools could facilitate the transition to the higher academic rigor of high school (Juvonen et al., 2004). However, in recent years, a number of districts have experimented with school grade configurations moving back towards K-8 schools rather than separate elementary and middle schools. Despite the movement, the impact of moving to K-8 schools is not entirely clear.

One could argue that a move to K-8 could adversely affect students as K-8 schools are often larger schools with less intimate relationship between

students/families and teachers (Feldlaufer et al., 1988; Midgley et al., 1989). In addition, the move to K-8 schools could adversely affect elementary students as they will be exposed to much older students, which could create an intimidating environment. On top of these arguments of educational arguments, one could also argue that a move to K-8 schools could be expensive as districts may have to make significant investments to modify or build new facilities.

Advocates could counter that eliminating the transition from elementary to middle schools can reduce student stress, who are already feeling stress from social and biological changes from the onset of puberty (Eccles et al., 1984; Eccles and Midgley, 1989; Juvonen et al., 2004). This argument has some support as research by Elias et al. (1985) found that students report a high level of stress from the complex, new social world in middle school. Furthermore, research by Rudolph et al. (2001) shows that students with maladaptive self-regulatory beliefs, such as decreased perception of academic control and importance, report more pressure during the transition to middle schools. Therefore, by reducing student stress, learning may improve for students. Advocates could also argue that teacher and student relations change during the transition from elementary school to middle school. Research suggests that teachers in middle schools are on average less caring, friendly and supportive than their counterparts in elementary schools (Feldlaufer et al., 1988). Deterioration in teacher/student relations in middle school could adversely affect students (Midgley et al., 1989) because positive relations with adults other than parents are important to the social and emotional development of young adolescents (Miller, 1970). These theoretical claims by advocates are supported by empirical research on student mobility, which suggests that student moves between schools can have adverse impacts on students (Hanushek, Kain and Rivkin, 2004; South, Haynie, and Bose, 2007; Ozek, 2009;

Xu, Hannaway, and D'Souza, 2009; Schwartz et al., 2011). [1] Because K-8 schools could eliminate a move from an elementary to middle school, there could be positive effect for students in K-8 schools.

Despite this general evidence on student mobility, the existing literature paints an ambiguous picture on the transitional effect from elementary to middle schools. Some studies find adverse effects of mobility from elementary school to middle school (Bedard and Do, 2005; Cook et al., 2008; Schwartz et al., 2011) while other studies find no effect or a positive effect on achievement (Weiss and Kipnes, 2006; Gunter and Bakken, 2010; Lippold et al., 2013;). However, this research either focuses on the effect of K-8 schools, or do not deal with the non-randomness of students choosing to enroll in K-8 schools versus separate elementary and middle schools.

Two recent studies more narrowly focus on whether students have stronger performance in stand-alone middle schools or K-8 schools and try to address possible endogeneity (Rockoff and Lockwood, 2010; Schwerdt and West, 2013). More specifically, both sets of authors instrument for the grade configuration during middle school years with the grade configuration of the school that the child attended in grade 3. The essential assumption for the instrument is that any unobserved shocks to achievement during the transition are not anticipated nor do they affect the choice when in grade 3 of a school with a specific grade configuration. However, if this second assumption does not hold, their instrument only accounts for a switch to a K-8 school after grade 3 and does not account for

[1] However, it should be noted that there are two types of mobility—non-structural and structural mobility. Non-structural moves are the result of student choice. Students move to another school because of observed or unobserved preferences. Structural moves are related to grade configuration. Students move to another school because they finished the terminal grade at their current school and have to start the next grade in another school in a higher grade. It is important to distinguish between the two types of mobility as their policy implications are different. In this study we focus on the effect of structural moves.

the possibility that parents choose to send their child to a K-8 or separate elementary/middle school sequence prior to that time.

In this current paper, we contribute to the existing literature by examining whether the previous findings hold up when employing an alternative identification strategy. More explicitly, we employ a geographic quasi-experimental design much like a regression discontinuity approach taking advantage of school closures in an anonymous midsize district. The closings led to new geographic boundaries sending some students to K-8 schools that previously were assigned to separate elementary and middle schools and vice versa. This approach prevents possible bias not only from students who switch once they enter the school system, but also before they enter the school system at Kindergarten. Using this alternative approach, much like the Rockoff and Lockwood (2010) and Schwerdt and West (2013) papers, we find some evidence for adverse transitional effects of attending a middle school. However, unlike these papers, we do not find long-term effects from attending a middle school. In addition, while Rockoff and Lockwood and Schwerdt and West instrumental variable (IV) approach (henceforth, referred to as "grade 3 IV approach") conceivably addresses selection into middle schools, it does not address selection into elementary schools. Our geographic-experimental design, on the hand, addresses both selection into middle and elementary schools and therefore, is a preferred approach. When examining differences in performance between students in elementary grades in a K-8 school versus a separate elementary school, we find in advantage in achievement for students in a separate elementary school.

II. Institutional Background

For the study, we have access to the anonymous district's longitudinal student-level data warehouse. The district has maintained student-level data on enrollment, demographics, residential location, and student outcomes since the late

1990s. The data set links student outcomes with the student's grade and school of attendance, neighborhood characteristics (based on student's residential location), time varying student characteristics, including free- and reduced-price lunch (FRL), limited English proficiency (LEP), and special education status, as well as time-invariant demographics including gender and race/ethnicity. One of the features of the data system that is fairly unique is the rich geographic information, including the addresses of students and schools, and school feeder patterns. In addition, information from Census and American Community Survey tract summary data has been linked to each student using their address for each year. Finally, the data set includes scores for the standards-based accountability tests and the district administered nationally-normed Terra Nova test. Up to the 2003-04 school year, the standards-based accountability test was administered in fifth, eighth, and eleventh grades. Third grade was added in year 2004-05 and expanded the next year to include all grades between third and eighth grade as well as eleventh grade. For the Terra Nova, we have first and second grade math test scores since 2002-03 and reading since 2003-04, which allows us to have a measure of student performance prior to grades tested for the state accountability test. While the Terra Nova is not psychometrically aligned with the state standards based accountability test, the two tests are highly correlated. To have the two tests on the same scale, we normalize these test scores by subject, grade and year with a mean of zero and standard deviation of one.

For the analyses, we include students that meet the following conditions:[2] (1) the student was in grade 5 or lower in the 2005-2006 school year, (2) the student

[2] Condition (1) and (2) are imposed to make the samples for the IV approach and geographical quasi-experiment approach comparable. We have similar estimation results without them. For the same purpose of comparison, we do not require the data to be a balanced panel data, which is used in the previous studies, as we want to maximize the sample, especially for the geographic quasi-experiment that we will discuss later. For the IV approach we also have similar estimation results with a balanced panel data. Both estimation results are available upon request.

was enrolled in grade 6 or higher by the 2010-11 school year, (3) the student attended a school for which the earliest grade was either kindergarten or grade 6,[3] (4) the student had test scores in at least one grade and had no grade skipping or retention, and (5) and the student did not have missing grade configuration information. In total there are 5,329 students that met these conditions. For these students, the average age in 2006 is 9.29 and 50 percent are male. In terms of race, 41 percent of the students are white, 50 percent are black and the remaining 9 percent are of other races. Thirty-six percent of the students were in a stand-alone middle school during our observation period with the remainder attended a K-8 school.

A simple pairwise comparison in achievement between the students from the stand-alone middle schools and K-8 schools is insufficient for us to draw any conclusion about the causal effects of moving to stand-alone middle school, because the grade arrangement of the school (e.g., a middle school or K-8 school) could affect the choice of school by families. Choice of school could be exercised by moving to a different location within the district or by opting for one of the many magnet school programs offered. Such self-selection can lead to biased results as their choice to attend a K-8 school may be driven by non-random factors, including the hopes of gaining a better academic experience for the student.

We implement two strategies to deal with this potential selection bias. First, we employ the grade 3 IV approach used by Rockoff and Lockwood (2010) and Schwerdt and West (2013), which addresses students switching between schools after attending an initial school. The second approach is a geographic quasi-experimental approach that mimics a geographical regression discontinuity design.

[3] There are elementary and middle schools within the district that start in grade other than Kindergarten or grade 6. We exclude them from the analysis, as we want to focus on the comparison between K-5, K-8 and stand-alone middle school (6-8).

Our design is similar to an approach used by Black (1999) to estimate the capitalized value of education in homes. Our approach addresses the endogeneity due to both students who chose to switch between schools as sixth grade approaches and students who chose one of these school types when they enter the school system.

III. Instrumental Variable Approach

The grade 3 IV approach introduced by Rockoff and Lockwood (2010) takes into account the possible endogeneity of students first attending a K-5 school and then, after grade 3, switching to a K-8. Such moves may be correlated with unobserved contributions to achievement such as a bad school experience or a residential move. In the IV approach, the authors define treatment as attending a stand-alone middle school and then instrument for middle school entry in grade 6 or 7 using the terminal grade of the school a student attended in grade 3. Specifically, they instrument for entering middle school in grade 6 with an indicator for whether the school that the student attended in grade 3 had a terminal grade of 5. The essential assumption for this approach is that any unobserved contributions to achievement do not affect the choice, prior to grade 3, of a school with specific grade configuration.

As a first step we replicate this grade 3 IV approach so that we can later compare the results from their approach to our new approach of using a geographic quasi-experiment. To carry out the grade 3 IV approach, we restricted the sample by dropping students with missing enrollment information at grade 3. [4] [5] Using these data, we estimate the same treatment effect as the earlier studies, i.e., the

[4] This is in addition to the five restrictions we list out in the data description section.
[5] Those students may have missing information about the ending grade of the school they were enrolled at grade 3, or they may had already finished grade 3 by 1999, the first year in our data set.

effect of transitioning to a stand-alone middle school as compared to a K-8 school on student achievement, by using the following equation:

$$y_{ig} = a_i + b_g + c_g m_i^6 + e_{ig} \quad (1)$$

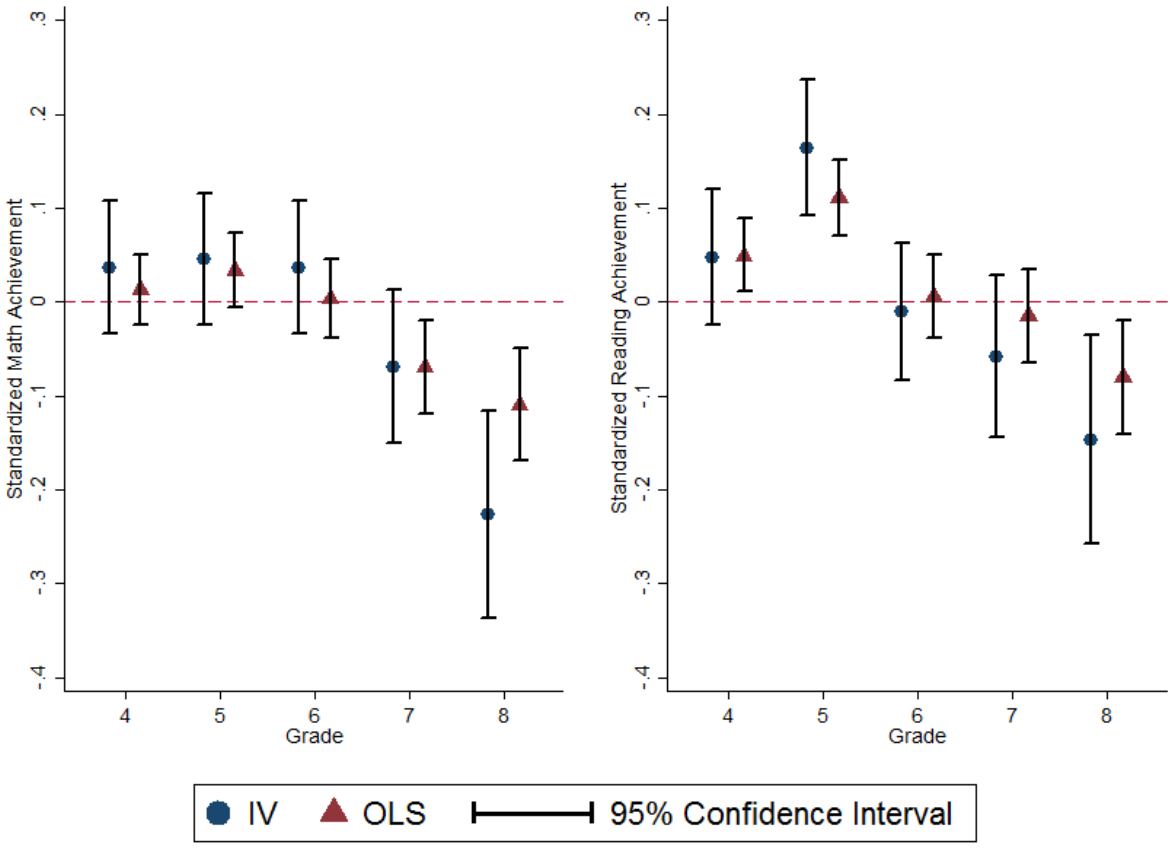
where y_{ig} is the achievement of student i in grade g, a_i is the student-specific fixed effect, b_g is the grade-specific fixed effect, m_i^6 is the indicator of whether student i attends a middle school in grade 6 multiplied by a grade-specific parameter c_g, and e_{ig} is the student-grade-specific unobserved error term. We omit the g subscript from the middle school indicator to denote that it does not vary by grade for a given student. By including a grade-specific coefficient we can examine the treatment effect by grade, including grades prior to attending a middle school. As was done in the previous studies, we set $c_g = 0$ for $g=3$, imposing the restriction that the school's grade configuration does not have an impact on student achievement in grade 3. The estimates of c_g, $g>3$, indicate the achievement difference in grades 4-8 between students who will be enrolled in a middle school and students who will be enrolled in a K-8, relative to their achievement in grade 3.

The first stage of the grade 3 IV approach involves predicting middle school enrollment in 6th grade based on the terminal grade of the school attended in third grade. Like the earlier studies, we find that terminal grade is strongly predictive of attending a middle school— the probability of attending a stand-alone middle school in grade 6 is approximately 56 percent greater for the third-grade students who were enrolled in an elementary school with a terminal grade of grade 5. While this relationship is strongly predictive, it is somewhat weaker than that found in the earlier studies, presumably because school closings disrupted this relationship for some students.

Figure 1 shows the estimates of the effect of middle school enrollment on achievement using this IV method. We also present the results of OLS estimation

for the purpose of comparison. The details of the estimation results can be found in appendix Table A-1.

Figure 1: Impact of Enrolling in a Stand-Alone Middle School in Grade 6 on Achievement



Focusing on the grade 3 IV approach, we display the estimates not only during middle school grades, but pre-middle school grades to examine trends. One could interpret these estimates of pre-middle school grades as an estimate of the difference between attending a separate stand-alone elementary school from a K-8 school. However, neither Rockoff and Lockwood (2010) and Schwerdt and West

(2013) treated these estimates as unbiased estimate of the effect of attending a stand-along elementary school versus a K-8 school because the instrument does not control for the possible self-selection into the type of elementary school a student attends.

In examining these pre-middle school trends, much like Rockoff and Lockwood as well at Schwerdt and West, we find that the students who later attend stand-alone middle schools perform at least on par with students in K-8 schools in math. In reading, these students actually outperform K-8 students in grade 5 by 0.164 standard deviations. In discussing their own results,[6] Schwerdt and West (2013) suggest that the positive pre-middle school trends may be a reflection of either better school quality[7] in these schools or a selection into K-5 and K-6 (versus a K-8 school) that is correlated with learning trajectories. In other words, if the second explanation is true, the grade 3 IV approach may not completely remove the selection bias as a "bias-free" approach would have similar (and insignificant) achievement trajectories prior to attending a middle school. In interpreting the positive pre-middle school achievement trajectories (regardless of the explanation of these trajectories), Schwerdt and West notes that their subsequent negative estimates of middle school effects may be an upper-bound estimate of the effects of attending a stand-alone middle school. While Schwerdt and West argue that there is no plausible selection into K-5 or K-6 schools that would explain the drop in performance in the entry middle school grade, it does raise the question of whether there may be an alternative estimation approach that be more effective at dealing

[6] In Schwerdt and West (2013), the authors found positive math achievement trajectory estimates for students in fourth and fifth grade of 0.060 and 0.040 standard deviations, respectively. Similarly, the authors found a positive reading achievement trajectory of 0.058 for fourth graders. Similar prior achievement trajectories are found for students entering a middle school in seventh grade. Rockoff and Lockwood (2010) found for students entering a middle school in sixth grade a positive and statistically significant math and reading estimate in fifth grade of 0.053 and 0.080 standard deviations, respectively. Again, similar results are found for students entering a middle school in seventh grade.

[7] Rockoff and Lockwood (2010) suggested the same possibility.

with selection not only as a result of students switching once in the school system, but also from students' original decisions about the type of school to attend in Kindergarten. We later address these issues with our alternative identification strategy of the geographic quasi-experimental design.

In examining the middle school grades from our own analysis in Figure 1, there is at least some evidence across the estimates that their achievement levels drop both in the transition grade of sixth grade and later in grades 7 and 8. In some cases, these effects are not trivial. For instance, in the transitional sixth grade, student reading achievement drops from an achievement level of 0.164 in fifth grade to -0.010 in sixth grade—a drop of over 0.17 standard deviations. Furthermore, the achievement in grade 8 for students attending a separate middle school lags the achievement of students in K-8 schools by 0.226 and 0.146 standard deviations in math and reading respectively. Much like the estimates of Rockoff and Lockwood (2010) as well at Schwerdt and West (2013), our reading estimates may be upper-bound estimates due to the positive pre middle school achievement trajectory in grade 5.

Overall, these results are largely consistent with the results Rockoff and Lockwood (2010) as well as Schwerdt and West (2013) and suggest that accounting for the possible endogenous moves, there are both short-term and long-term adverse effects moving from elementary to a middle school. It is worth noting that the estimated effects from OLS are smaller in magnitude, which suggests that the naïve estimate that does not control for endogenous switch to a middle school may underestimate the negative effects of attending a middle school. However, we argue that the instrumental approach does not completely solve the problem of endogeneity as we contend that it does not account for the original decision to attend a separate elementary/middle school or K-8 school when first entering the school system, which we address in the next section.

IV. Geographic Quasi-Experiment

To account for the original decision of whether to attend a separate elementary and middle school versus a K-8 school, we leverage the fact that the anonymous district closed 20 schools (or about one-fourth of all schools) at the conclusion of the 2005-06 school year because of accumulated surplus capacity. Many closed middle schools were replaced by expanding existing elementary schools from K-5 to K-8 with the hope that the shift in grade configurations would reduce the disruption often associated with switching schools. As a result, there were 13 new K-8 schools at the beginning of the 2006-07 school year with new geographic boundaries. These new school boundaries provide an opportunity for a strong identification strategy as we can compare students on one side of the boundaries attending a stand-alone middle school to students on the other side of the boundaries attending a K-8 school. In essence, this mimics a "spatial" regression discontinuity (RD) approach where equivalent comparison groups are created (both in observed and unobserved characteristics). We can observe students in neighborhoods that were originally assigned to the same school before the closure and assigned different schools after the closure. From these patterns, we can observe pairs of students who live very close to each other that were assigned to the same school before the closure but were assigned to different types (K-5 vs. K-8) of schools after the closure. They should have similar observed and unobserved characteristics, including similar preferences for the various types of school configurations. By comparing their achievements we are able to obtain the causal effect of the K-5/middle configuration relative to the K-8 configuration.

Table 1 provides additional details about the number and percentage of first through fourth grade students in 2005-06 school year that were reassigned to and from K-8 schools as well as to and from K-5 schools as a result of the new school boundaries. These students make up our baseline set of students for the geographical analysis. We divide the students into those previously assigned to a

continuing school (i.e., a school that continues to operate) and those assigned to a closing school. We present the number and percentage of students reassigned from a continuing K-5 or K-8 schools to another K-5 or K-8 school, how many are keeping their assignment at their continuing K-5 and K-8 schools, and how many are reassigned from closed K-5 or K-8 schools. In total, over 400 students were reassigned from a K-5 school to a K-8 school while just 100 students were reassigned from a K-8 school to a K-5 school.

Table 1: Amount of Students by the Type of Assignment

From	**To**	**Number of Students**			**Percent of the total students**		
Continuing Schools		5285			77.4		
Continuing K-5			2750			40.3	
	Another K-5			106			1.6
	K-8			25			0.4
	The Same K-5			2619			38.4
Continuing K-8			2535			37.1	
	K-5			38			0.6
	Another K-8			77			1.1
	The Same K-8			2420			35.5
Closing Schools		1540			22.6		
Closing K-5			1239			18.2	
	Another K-5			792			11.6
	K-8			447			6.5
Closing K-8			301			4.4	
	K-5			100			1.5
	Another K-8			201			2.9
Total Students		6825	6825	6825	100	100	100

We should note that using long-term existing school boundaries most likely would not create equivalent groups as many families may choose their residence on one side of the boundary based upon the characteristics of the school offerings, including whether it is a K-8 school. However, because the district's rezoning

created unanticipated new boundaries, very few families were able to move to new locations in response to the rezoning, at least in the short run.[8] Thus, the rezoning can be viewed as an exogenous shock creating an opportunity to create strong comparison groups.

Using these newly formed school boundaries, we create strong comparison groups for our analysis. Two students who lived close to each other and thus previously were assigned to the same schools before the closures, but were assigned to different schools of different types after the closures, should be very similar in terms of both observed and unobserved characteristics. However, like in a regression discontinuity analysis, the broader the bandwidth (in this case, measured by geographic distance), the more likely the groups will differ in observed and unobserved ways. We use bandwidths of 0.3, 0.2 and 0.1 miles and identify students who lived within bandwidths of at least one other student who was previously assigned to the same school but was reassigned to a different type of school (separate K-5 and middle schools versus K-8 schools). We also restricted the sample to students who lived in the same place in 2005 and 2006, were from grade 1 to 4 in 2005 and had no grade skipping or retention through 2005 and 2006. By making these restrictions, we exclude the students who were assigned to a different school because of residency change, who were enrolled in middle school grade before the school closure, and who made abnormal progress through grades respectively, leaving us with students who are likely to be similar except for differences in their new school assignment.[9] In total there are 1,395 such students reassigned to 29 schools for 0.3-mile distance, 1,003 students reassigned to 29

[8] Furthermore, the boundaries were not created by a political process, but instead by administrators whose goal was exactly filling the seats in the schools that remained open. The school board explicitly accepted the superintendent's request to stay removed from the closing and reassignment process, only retaining the right to vote the final package up or down.

[9] For the geographic quasi-experimental approach it is not necessary to exclude the students with missing information about grade configuration at grade 3, as what we did for the instrumental approach. Our results and conclusions do not change significantly if we exclude them.

schools for 0.2-mile distance and 503 students reassigned to 28 schools for 0.1-mile distance.

Table 2 summarizes differences in observable demographic characteristics for students within 0.3, 0.2, and 0.1 miles bandwidths by types of the schools into which students were rezoned. The descriptive statistics show that the students rezoned to a K-5 school are quite similar with the counterparts rezoned to a K-8 school across observable characteristics across the bandwidths. For the bandwidths of 0.1, 0.2, and 0.3 miles, two, five, and two of the observable characteristics are statistically significant at the 5 percent level, respectively, but in nearly all cases, these differences are small in magnitude. For the analysis, we include all three bandwidths for robustness with 0.3 miles bandwidth providing the most power to detect effects because of the larger sample size.

Table 2: Balance Check of Observable Characteristics

Observed Characteristics	**0.3 Mile**			**0.2 Mile**			**0.1 Mile**		
	To K5	**To K8**	**Diff (t-test)**	**To K5**	**To K8**	**Diff (t-test)**	**To K5**	**To K8**	**Diff (t-test)**
Age of students in 2006	9.11 (1.20) [763]	9.21 (1.21) [632]	-0.10 (0.06)	9.07 (1.20) [551]	9.26 (1.22) [452]	-0.19** (0.08)	8.99 (1.20) [264]	9.31 (1.23) [239]	-0.32*** (0.11)
Male	0.48 (0.50) [763]	0.52 (0.50) [632]	-0.04 (0.03)	0.48 (0.50) [563]	0.53 (0.50) [452]	-0.05 (0.03)	0.47 (0.50) [264]	0.54 (0.50) [239]	-0.07 (0.04)
White	0.36 (0.48) [763]	0.38 (0.49) [632]	-0.02 (0.03)	0.37 (0.48) [551]	0.35 (0.48) [452]	-0.03 (0.03)	0.30 (0.46) [264]	0.29 (0.46) [239]	0.01 (0.04)
Black	0.52 (0.50) [763]	0.54 (0.50) [632]	-0.02 (0.03)	0.51 (0.50) [551]	0.59 (0.49) [452]	-0.07** (0.03)	0.59 (0.49) [264]	0.64 (0.48) [239]	-0.05 (0.04)
Pct. of free or reduced price lunch	0.64 (0.48) [763]	0.64 (0.48) [632]	0.00 (0.03)	0.65 (0.48) [551]	0.63 (0.48) [452]	0.03 (0.03)	0.71 (0.46) [264]	0.73 (0.45) [239]	-0.02 (0.04)
Pct. of limited English proficiency	0.06 (0.24) [763]	0.02 (0.15) [632]	0.04*** (0.01)	0.06 (0.24) [551]	0.02 (0.13) [452]	0.04*** (0.01)	0.06 (0.24) [264]	0.03 (0.16) [239]	0.04* (0.02)
Pct. of gifted student	0.08 (0.28) [763]	0.05 (0.21) [632]	0.04*** (0.01)	0.08 (0.27) [551]	0.04 (0.21) [452]	0.03** (0.02)	0.04 (0.19) [264]	0.02 (0.14) [239]	0.02 (0.02)

Pct. of student with special need	0.26 (0.44) [763]	0.29 (0.46) [632]	-0.03 (0.02)	0.25 (0.43) [551]	0.29 (0.45) [452]	-0.04 (0.03)	0.27 (0.45) [264]	0.31 (0.46) [239]	-0.04 (0.04)
Grade in 2005	2.47 (1.11) [763]	2.55 (1.10) [632]	-0.07 (0.06)	2.43 (1.11) [563]	2.58 (1.12) [467]	-0.14** (0.07)	2.40 (1.11) [264]	2.61 (1.11) [239]	-0.21** (0.10)
Math Score, 2005	0.06 (0.97) [739]	0.03 (0.94) [602]	0.03 (0.05)	0.03 (0.96) [545]	0.01 (0.95) [448]	0.02 (0.06)	-0.11 (0.90) [256]	-0.00 (0.94) [228]	-0.11 (0.08)
Reading Score, 2005	0.07 (0.94) [736]	-0.01 (0.92) [602]	0.08 (0.05)	0.06 (0.95) [543]	-0.04 (0.96) [448]	0.09 (0.06)	-0.01 (0.92) [255]	-0.05 (0.92) [228]	0.04 (0.08)

Standard errors are reported in parentheses. Sample sizes are reported in brackets. ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively.

Intent-to-treat analysis

Like many treatments, some students do not comply with their assignment. For instance, the district has magnet schools, which allows students to opt out of their assigned schools. Therefore, we first do an intent-to-treat (ITT) analysis, which examines whether merely being assigned to a K-5/6-8 or a K-8 school has an impact on student achievement. We estimate the ITT effect of being assigned to a K-5/6-8 sequence of schools, by fitting the following equation:

$$y_{igtp} = a_i + d_p + S^{gt} + S^{gtA5} + e_{igtp} \quad (3)$$

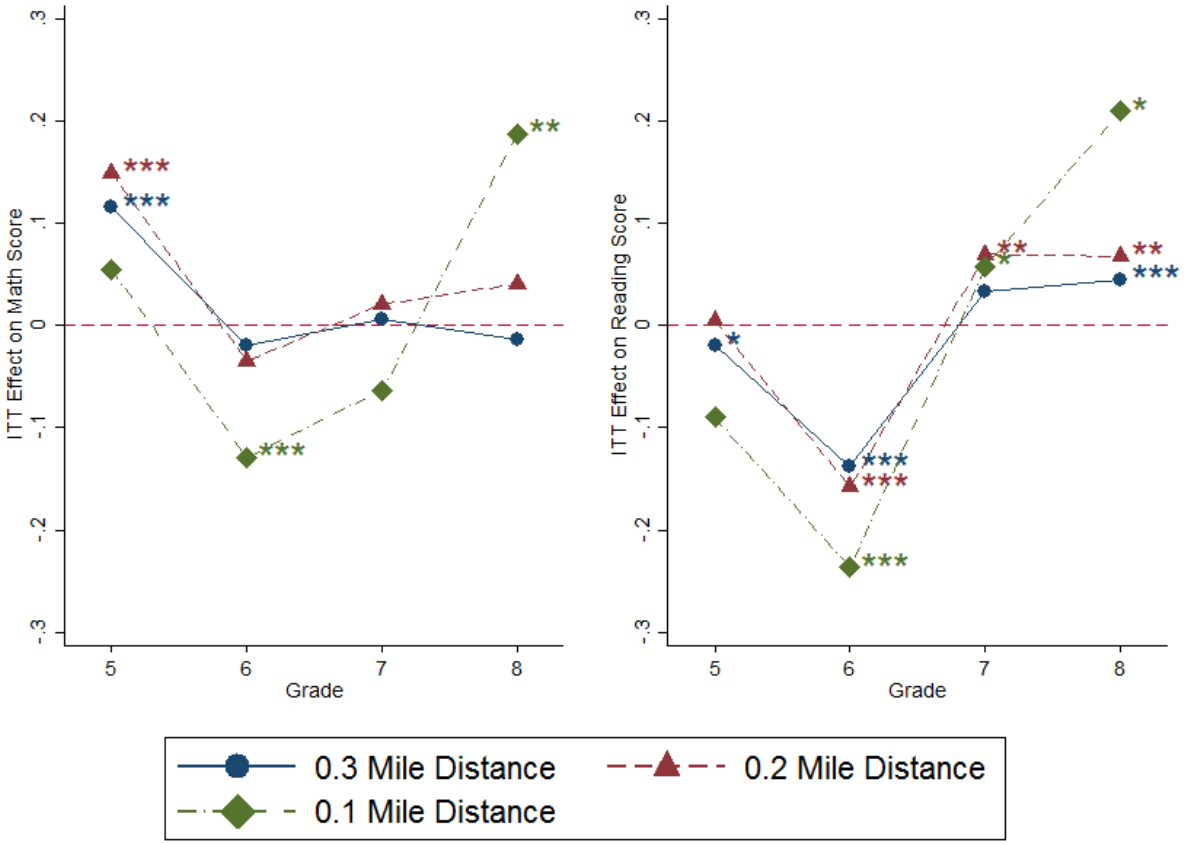
where y_{igtp} is the achievement of student i in grade g, in period t, and is a member in pair p. We define period as either prior to school closures (*t=0*) or after school closures (*t=1*). The parameters a_i and d_p are the individual and pair fixed effects respectively. The parameter S^{gt} is a fixed effect for each combination of grade and period. The parameter S^{gtA5} is a fixed effect for students assigned to K-5/6-8 schools in 2006, for each combination of grade and period. This parameter is the ITT effect, as it estimates the difference in relative achievement for the students assigned to K-8 following the closures.

The ITT effects are presented in Figure 2 and with further details in Appendix Table A2. In the figure, just as the case for Rockoff and Lockwood (2010) and Schwerdt and West (2013), being assigned to a stand-alone middle

school is the treatment. Therefore, a negative effect would suggest that there are adverse effects from being assigned to a middle school relative to a K-8 school and would provide support for a K-8 policy. The opposite would be true for positive effects.

Overall, the ITT results provide some evidence of a negative transition effect to a stand-alone middle school in grade 6, which supports the results found both by Rockoff and Lockwood and Schwerdt and West. However, unlike these previous studies, we do not observe persistent long-term effects in grades 7 and 8. In fact, we observe some statistically positive (and in some cases, nontrivial) effects. These results raise questions about the robustness of the results from the previous papers and the policy implications from these papers.

Figure 2: Impact on Achievement of Being Assigned to K-5/6-8 School



Note: ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively.

Treatment-on-treated analysis

The ITT are of interest because they capture the average impact of the policy over all of the students potentially affected by it. However, the ITT results do not measure the effect of the policy on students actually complying with their assignment. To estimate the effect for students who actually enroll in a K-5/6-8 sequence of schools, we have to account for non-compliance using a treatment-on-treated (TOT) analysis. We take an approach similar to a "fuzzy" RD design and use school assignment based on the geographic boundaries as an instrumental

variable to estimate the causal effect of enrolling in a middle school. More formally, to estimate the TOT effect, we use the indicator of assignment as an instrumental variable for enrollment and fit the following equations:

$$\begin{cases} E5_{ip} = f_i + l_p + S^{gt} + S^{gtA5} + u_{ip} & (4) \\ y_{igtp} = a_i + d_p + S^{gt} + S^{gtE5} + e_{igtp} & (5) \end{cases}$$

where $E5_{ip}$ are the interactions of the indicator of whether student i enrolls in a middle school in grade 6 with indicators for grade, for time or both.

Table 3 presents the effect of being assigned to K-5/6-8 school sequence on actual enrollment in a stand-alone middle school. The results suggest that assignment is predictive of the type of school a student attends, although there are many students who do not end up following their assigned paths. Therefore, just like the approach using terminal grade as an instrument, the TOT results can be interpreted as local average treatment estimates.

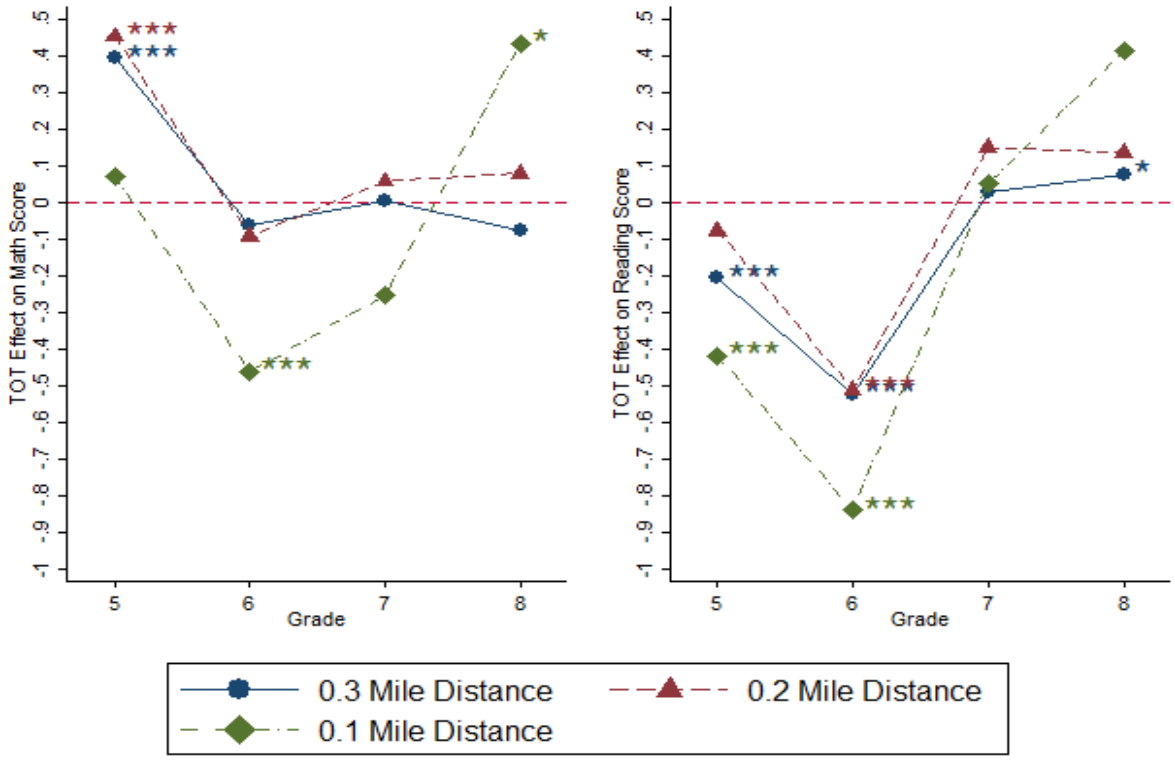
Table 3: Effect of Assignment to K-5/6-8 Schools on Enrolling in a Middle School

	Bandwidth		
	0.3 mile	**0.2 mile**	**0.1 mile**
Overall	0.263*** (0.004)	0.307*** (0.005)	0.299*** (0.100)
Grade in 2005 (immediately prior to school closures):			
Grade 1	0.215*** (0.008)	0.254*** (0.011)	0.258*** (0.022)
Grade 2	0.168*** (0.007)	0.223*** (0.011)	0.179*** (0.020)
Grade 3	0.193*** (0.008)	0.206*** (0.011)	0.264*** (0.021)
Grade 4	0.439*** (0.006)	0.508*** (0.009)	0.492*** (0.018)

Note: Robust standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively.

Of greatest interest are the effects of the assignment policy on test scores, which are shown in Figure 3 and with details in Appendix Table A3. Again, enrolling a stand-alone middle school is the treatment. Therefore, a negative effect would suggest that there are adverse effects from enrolling a middle school relative to a K-8 school and would provide support for a K-8 policy. The opposite would be true for positive effects. As with the case for the ITT analyses, we observe some evidence of a negative transition effect to stand-alone middle schools. However, like the ITT analyses, we observe some positive (and sometime large) effects by both grades 7 and 8 in the gains analyses. Again, these results are in stark contrast to the results we observed in our own estimates of the effects from the grade 3 IV approach of Rockoff and Lockwood (2010) and Schwerdt and West (2013), which showed long-term negative effects from enrolling in a middle school.

Figure 3: Impact on Achievement of Enrolling in a Stand-Alone Middle School at Grade 6



Note: ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively.

Overall, while these results provide some evidence of adverse transition effects for those students transitioning to a stand-alone middle school, our analyses do not show long-term adverse effects from attending a middle school. Therefore, when controlling for the possible endogenous selection at the entry grade of the school system as well as for switching between schools after third grade, our geographic quasi-experimental approach shows less support for K-8 schools than the previous research which accounted only for the endogenous switching after third grade.

V. Effect of Studying in a K-5 school

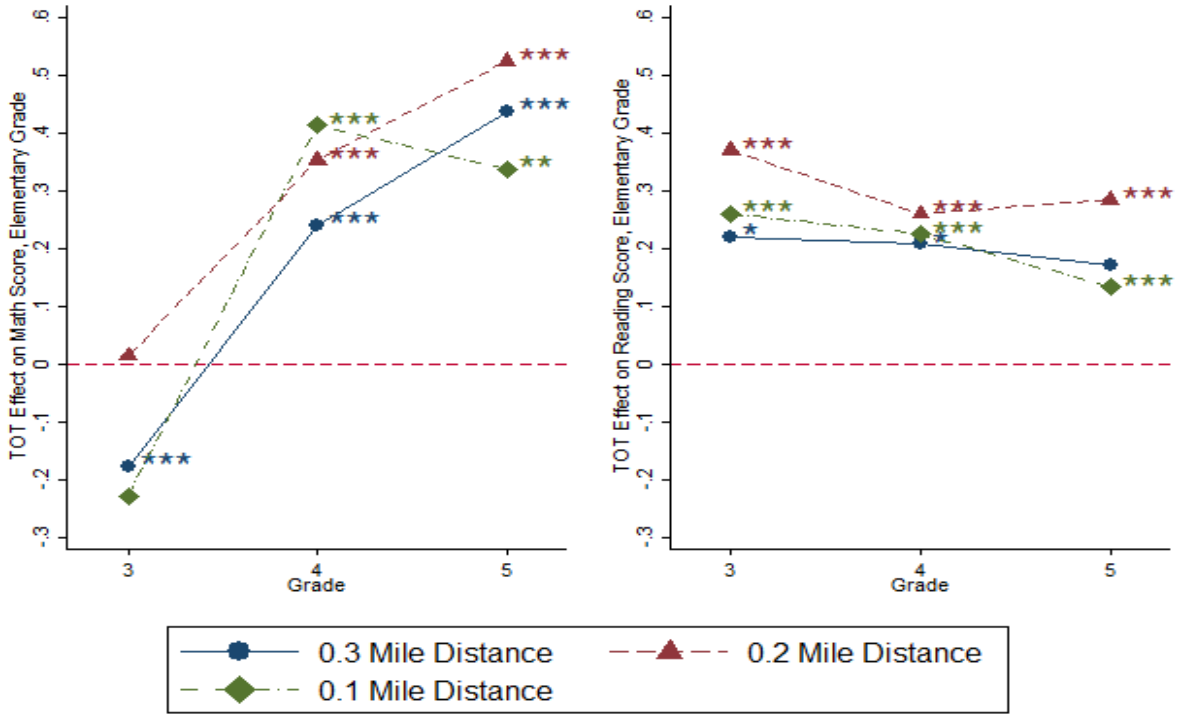
While both Rockoff and Lockwood (2010) and Schwerdt and West (2013) estimated pre-middle school trends of student achievement, which could be interpreted as the effect of the difference between attending a separate stand-alone elementary and a K-8 school, neither set of authors treated these estimates as unbiased effects of attending stand-alone elementary schools because the estimator admittedly did not account for choice of school configuration during the elementary grades. In our case, the school closures provide us an opportunity to rigorously study another treatment effect associated with grade configuration—the effect of attending K-5 school for elementary students. One could speculate that elementary students in a K-8 school (i.e., students attending grades K-5) could experience adverse effects from going to school with much older students in the same campus. For instance, these much older kids could physically intimidate younger students. In addition, these elementary students would most likely attend a much larger and less intimate school than if they went to a K-5 school.

To estimate the effect for these elementary students, the identification strategy is similar with the previous section in which we employ TOT estimate. Here we define treatment as whether the student is attending a K-5 school in 2006 right after the school closure. We use the assignment of students to schools as the instrumental variable. While not reported here, the results of the first stage indicate that being assigned to a K-5 school increases the likelihood of attending a K-5 school in 2006. Again, assignment does not perfectly predict enrollment, which again suggests that our results are local average treatment estimates.

In Figure 4 (and with details in Appendix Table A4), we present the TOT estimates of enrolling in a K-5 school before grade 6. While we do not consistently find positive or negative math effects in grade 3, the math results generally suggest that there are statistically positive effects of large magnitude for students in fourth grade and these effects generally linger into fifth grade. The reading results

consistently show positive effects in all three grades. Combined with the fact that we found no long-term negative effects for students in middle schools relative to K-8 schools, this suggests that K-8 schools may not lead to positive benefits for middle school students and lead to adverse effects for elementary students.

Figure 4: Impact of Enrolling in a K-5 School on Achievement for Elementary Students



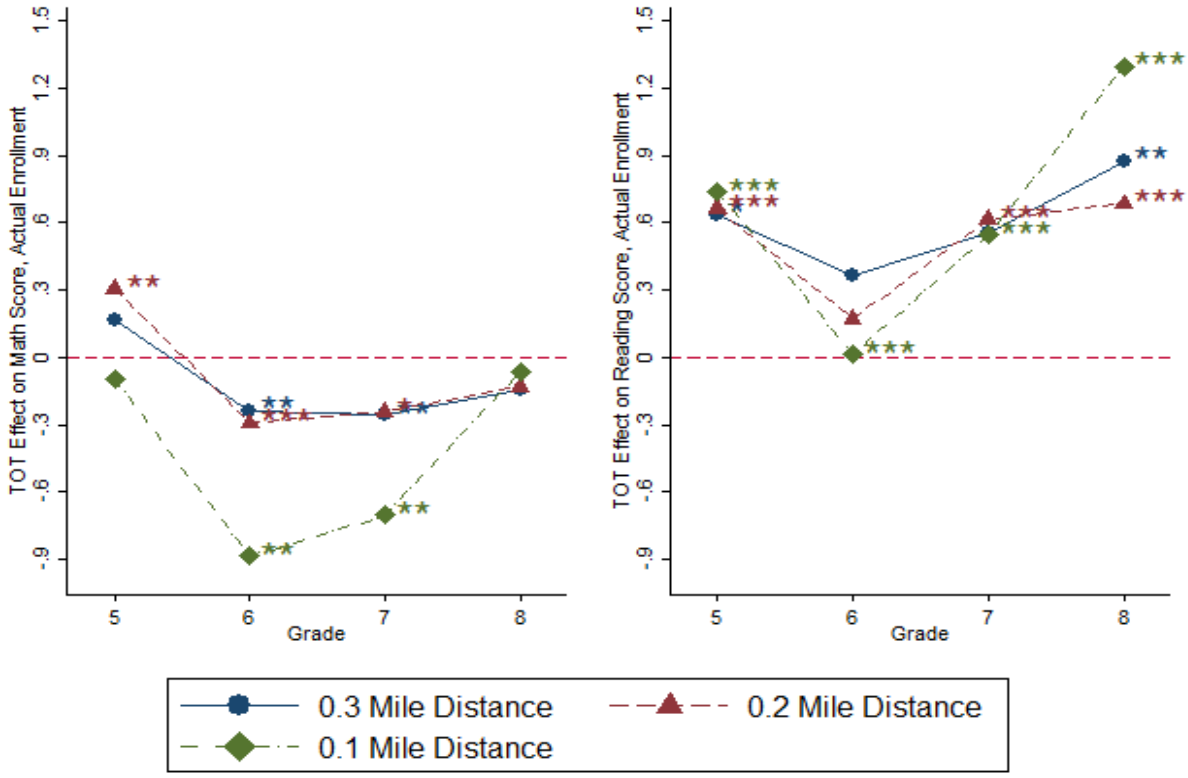
Note: ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively

VI. Robustness Check

In our analysis so far, we identify the pair of students by choosing the students who were assigned to the same school before the school closure but were reassigned to different types of schools after the school closure. There are alternative ways to identify pairs. For example, those students assigned to the same school in 2005-06

school year were not necessarily enrolled in the same school. The students living close to each other and assigned to the same school are very likely to be similar in both of observed and unobserved characteristics. However, this may not be the case if one student does not enroll in the assigned school, exercising choice to enroll in another school instead. In Figure 5 below (for details see appendix Table A5), we re-define the pairs of students by choosing those who indeed were enrolled in the same school before the school closure and keeping all of the other filters. For reading, much like the results from the implementation of grade 3 IV approach in previous papers (Rockoff and Lockwood, 2010; Schwartz and West, 2013), we do find some negative effects in grades 6 and 7. However, like our geographic approach and unlike the results from the grade 3 IV approach (either in our implementation or in the previous papers implementation of the grade 3 IV approach), these negative effects do not linger. Therefore, the long-term outcomes are more consistent with our preferred geographic approach as opposed to grade 3 IV approach. For math, the results align well with the results from the geographic approach in figure 3 and do not align well with results from the grade 3 IV approach (either from our implementation or the previous papers implementation of the grade 3 IV approach). Given that our primary purpose of the analysis is to see if the original results from grade 3 IV approach (used by previous research) are robust, both the reading and math results at least raises questions about the robustness of the grade 3 IV approach and provides support to our long-term results in grade 8 from our preferred geographic approach.

Figure 5: Impact of Enrolling in a Stand-Alone Middle School at Grade 6 on Achievement, Paired by Prior Actual Enrollment



Note: ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively.

One possible critique of our geographic approach is that inferences regarding the impact of attending a K-8 versus a middle school may be limited to situations in which many existing schools are closed and capacity in K-8 schools is expanded. The shift to K-8 schools in the study district was part of a larger reform of closing schools, which required many students to transition to a new school. Therefore, our geographic analysis may only have implications for a policy that causes students to transition to new schools. However, it should be noted that if a district or state adopted a K-8 policy, many students would transition to new

schools. Therefore, our geographic IV estimates do have important implications for students that transition to a different school, at least in the short run.

Finally, a major point of our analysis is to see if the findings from the grade 3 IV approach employed by the previous papers are robust to an alternative identification (and we argue, a more rigorous) strategy. The fact that we found similar results to the previous papers using their IV approach provides some confidence that our results of using the quasi-geographic experimental design are not due to applying our estimator to a district that is closing schools.

VII. Discussion

In this paper, we examine the efficacy of a move towards K-8 schools in place of a separate elementary and middle schools. While most of the early literature did not address the possible endogenous selection into school configuration, two recent papers use an IV approach in which they use the terminal grade of the school a student attends in third grade as an instrument (Rockoff and Lockwood, 2010; Schwerdt and West, 2013). While this approach may account for students switching between schools once they are in elementary schools, we argue that it does not account for the endogenous choice of whether to attend a K-8 school at the point of entry into the school system (e.g., students entering Kindergarten).

In our analysis, we first employ the same "grade 3 IV approach" that was used by the two previous papers and find similar results. We then employ an alternative approach that leverages the fact that our study district closed 20 schools and created new geographic boundaries to reassign the displaced students, providing an opportunity to use a geographical quasi-experimental design similar to an approach used by Black (1999) to estimate the capitalized value of education in homes. This approach deals with endogenous enrollment from students choosing to attend a K-8 or separate elementary and middle schools by students who chose to switch between schools once they have entered a school as well as by students

who chose one of these school configurations when they enter the school system. We then compare the results from the two approaches.

Our results from employing the grade 3 IV approach are similar to those in the previous papers, which suggest that attending a stand-alone middle school can have adverse transitional effects (i.e., an adverse effect for students in the grade they transition to the middle school) as well as adverse long-term effects in later grades. However, when we employ our preferred geographic quasi-experimental approach, we observe some similar adverse transitional effects, but these adverse effects disappear in later grades. This raises questions to the robustness of the grade 3 IV approach and more importantly, raises questions regarding the merit of moving towards a K-8 policy.

It should be noted, however, that the two approaches estimate local average treatment effects for different groups. The local average treatment effect for the grade 3 IV estimator is the average effect for all students who attend schools of the same configuration of the school they attended in third grade. The local average treatment effect for the geographic quasi-experimental estimator is the average effect only for students affected by the school closures. Therefore, we cannot definitely conclude whether the differences in our results are because one approach removes a bias that affects the other or because the average effect is different for the two groups. One way to address this concern would be to employ the grade 3 IV approach to the sample of students in the geographic quasi-experimental approach. However, there is limited overlap between the two samples (which reduces the power to detect effects). The use of only students affected by school closures will limit the ability of the instrument used in the previous grade 3 IV approach (i.e., terminal grade of school attended in third grade) to predict middle school attendance, so we would not be able to distinguish student selection of school configuration from school assignments due to the new policy. Therefore, we have to rely on the conceptual argument that our geographic approach is a preferred

approach as it deals with endogeneity due both to selection prior to initial enrollment and to selection following third grade.

VIII. Conclusion

Grade configuration has been a controversial topic among policymakers and district leaders (Hough, 2005). It was traditionally believed that the separation between elementary and middle schools around grade 6 is a good model for the education of adolescents because middle schools can be a "bridge" between elementary and high schools catering to the special needs of children aged 11 - 13 (Tamer, 2012). However, the traditional use of stand-alone middle schools have been challenged fueled by recent research suggesting a move to middle schools can have both short- and long-term adverse effects on students (Rockoff and Lockwood, 2010; Schwerdt and West, 2013). These papers used an IV approach using the terminal grade of the school attended in third grade as instrument to account for endogenous moves between schools after third grade. However, we argue that these papers do not take into account the possibility of students endogenously choosing to attend a K-8 or separate elementary and middle schools at the point of entry into the school system. Our study uses an alternative identification strategy arising from school closures in a midsize district that created new exogenous geographic boundaries for schools and caused some students to be reassigned to K-8 or separate elementary and middle schools. With these new boundaries came an opportunity to create a quasi-experimental approach comparing students who live close to each other but on either side of the boundaries between different configurations of schools. Using this approach, we account not only for the endogenous moves between schools, but endogenous choice of school configuration at entry point.

Our findings from the geographic quasi-experimental design provide some evidence of adverse effects for middle school students in the transition year of grade

6, which is consistent with results from the Rockoff and Lockwood (2010) and Schwerdt and West (2013) papers. However, unlike these earlier papers, we do not find any lingering effects for middle school students in grades beyond the transition grade. Furthermore, we find adverse effects for elementary students enrolled in K-8 schools, which were not explored in the previous research in a manner that deals with endogeneity of the choice of K-5 versus K-8 school. The adverse effects for elementary students in K-8 schools combined with the lack of long-term adverse effects for students attending stand-alone middle schools does not provide support for K-8 schools as the previous research suggest. In fact, our results provide some evidence against K-8 schools as a policy. While further research needs to be conducted in a larger set of districts before definitive conclusions can be drawn, we argue that future studies should not only account for students switching to K-8 school after entering a school, but account for the configuration of school in which a student initially enrolls.

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Appendix

Table A1: IV Achievement Estimates of Enrolling in a Stand-Alone Middle School in Grade 6

	2SLS		OLS	
	Math Score	**Reading Score**	**Math Score**	**Reading Score**
Panel A: Estimate of Effects on Test Score Levels				
	(1)	(2)	(3)	(4)
Grade 4	0.037 (0.036)	0.048 (0.037)	0.013 (0.019)	0.050** (0.020)
Grade 5	0.045 (0.036)	0.164*** (0.037)	0.034 (0.020)	0.111*** (0.021)
Grade 6	0.037 (0.036)	-0.010 (0.037)	0.004 (0.022)	0.006 (0.022)
Grade 7	-0.069 (0.042)	-0.058 (0.044)	-0.069*** (0.025)	-0.015 (0.025)
Grade 8	-0.226*** (0.056)	-0.146*** (0.057)	-0.109*** (0.031)	-0.080*** (0.031)
Panel B: Gains based on the Estimated Coefficient in Panel A				
Grades 3 to 4	0.037 (0.036)	0.048 (0.037)	0.013 (0.019)	0.050** (0.020)
Grades 4 to 5	0.008 (0.031)	0.117*** (0.033)	0.021 (0.016)	0.061*** (0.019)
Grades 5 to 6	-0.009 (0.031)	-0.175*** (0.034)	-0.030* (0.017)	-0.106*** (0.019)
Grades 6 to 7	-0.105*** (0.037)	-0.047 (0.041)	-0.073*** (0.019)	-0.021 (0.023)
Grades 7 to 8	-0.158*** (0.055)	-0.088 (0.057)	-0.040 (0.025)	-0.065** (0.028)
Sample Size	24644	24587	24644	24587

Note: Robust standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively. Panel B reports differences between estimated coefficients in panel A. Significance levels are based on tests with the null hypothesis that estimated coefficients for consecutive grades are the same.

Table A2: ITT Achievement Estimates of Being Assigned to K-5/6-8 School

	Math			Reading		
	0.3 Mile	**0.2 Mile**	**0.1 Mile**	**0.3 Mile**	**0.2 Mile**	**0.1 Mile**
	Panel A: Estimate of Effects on Test Score Level					
Grade 5	0.116*** (0.016)	0.150*** (0.024)	0.055 (0.044)	-0.020 (0.018)	0.005 (0.025)	-0.090* (0.048)
Grade 6	-0.020 (0.018)	-0.035 (0.025)	-0.129*** (0.048)	-0.138*** (0.018)	-0.158*** (0.026)	-0.237*** (0.048)
Grade 7	0.006 (0.018)	0.021 (0.026)	-0.063 (0.050)	0.034* (0.020)	0.070** (0.028)	0.058 (0.055)
Grade 8	-0.013 (0.025)	0.041 (0.036)	0.188** (0.080)	0.045* (0.024)	0.068** (0.035)	0.210*** (0.068)
	Panel B: Gains based on the Estimated Coefficient in Panel A					
Grades 5 to 6	-0.136*** (0.014)	-0.185*** (0.020)	-0.184*** (0.038)	-0.118*** (0.014)	-0.163*** (0.020)	-0.146*** (0.037)
Grades 6 to 7	0.025 (0.016)	0.056** (0.022)	0.066 (0.044)	0.172*** (0.016)	0.228*** (0.023)	0.294*** (0.044)
Grades 7 to 8	-0.019 (0.023)	0.020 (0.033)	0.251*** (0.076)	0.011 (0.022)	-0.002 (0.032)	0.152** (0.062)
No. of Students	1378	996	500	1379	996	500
Sample Size	70621	34457	9201	70609	34448	9190

Note: Robust standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively. Panel B reports differences between estimated coefficients in panel A. Significance levels are based on tests with the null hypothesis that estimated coefficients for consecutive grades are the same.

Table A3: TOT Achievement Estimates of Enrolling in a Stand-Alone Middle School at Grade 6

	Math			Reading		
	0.3 Mile	**0.2 Mile**	**0.1 Mile**	**0.3 Mile**	**0.2 Mile**	**0.1 Mile**
	Panel A: Estimate of Effects on Test Score Level					
Grade 5	0.393*** (0.073)	0.454*** (0.088)	0.072 (0.169)	-0.207*** (0.078)	-0.077 (0.092)	-0.418*** (0.183)
Grade 6	-0.062 (0.071)	-0.091 (0.088)	-0.462*** (0.172)	-0.523*** (0.075)	-0.511*** (0.090)	-0.839*** (0.178)
Grade 7	0.006 (0.072)	0.058 (0.087)	-0.252 (0.173)	0.030 (0.080)	0.150 (0.095)	0.053 (0.198)
Grade 8	-0.079 (0.087)	0.080 (0.111)	0.435* (0.256)	0.076 (0.091)	0.136 (0.110)	0.412* (0.246)
	Panel B: Gains based on the Estimated Coefficient in Panel A					
Grades 5 to 6	-0.454*** (0.048)	-0.545*** (0.064)	-0.534*** (0.128)	-0.316*** (0.049)	-0.434*** (0.064)	-0.420*** (0.124)
Grades 6 to 7	0.067 (0.049)	0.149** (0.064)	0.210 (0.134)	0.553*** (0.052)	0.661*** (0.069)	0.891*** (0.144)
Grades 7 to 8	-0.085 (0.068)	0.022 (0.090)	0.687*** (0.228)	0.047 (0.071)	-0.014 (0.090)	0.359* (0.216)
No. of Students	1342	969	481	1342	969	481
Sample Size	68160	33291	8847	68149	33284	8839

Note: Robust standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively. Panel B reports differences between estimated coefficients in panel A. Significance levels are based on tests with the null hypothesis that estimated coefficients for consecutive grades are the same.

Table A4: Impact of Enrolling in a K-5 School on Achievement for Elementary Students

	Math			Reading		
	0.3 Mile	**0.2 Mile**	**0.1 Mile**	**0.3 Mile**	**0.2 Mile**	**0.1 Mile**
Grade 3	-0.177*** (0.051)	0.014 (0.066)	-0.229 (0.146)	0.221*** (0.048)	0.370*** (0.064)	0.260* (0.142)
Grade 4	0.240*** (0.045)	0.353*** (0.060)	0.413*** (0.126)	0.208*** (0.050)	0.260*** (0.066)	0.225* (0.134)
Grade 5	0.438*** (0.049)	0.525*** (0.066)	0.338** (0.142)	0.171*** (0.051)	0.285*** (0.067)	0.133 (0.148)
No. of students	928	634	308	929	635	308
No. of observations	39758	19551	5187	39750	19548	5179

Note: Standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively.

Table A5: Impact of Enrolling in a Stand-Alone Middle School at Grade 6 on Achievement, Paired by Prior Actual Enrollment

	Math			Reading		
	0.3 Mile	**0.2 Mile**	**0.1 Mile**	**0.3 Mile**	**0.2 Mile**	**0.1 Mile**
	Panel A: Estimate of Effects on Test Score Level					
Grade 5	0.166 (0.105)	0.305** (0.148)	-0.096 (0.369)	0.635*** (0.118)	0.662*** (0.166)	0.736* (0.384)
Grade 6	-0.238** (0.103)	-0.293*** (0.146)	-0.884** (0.346)	0.363*** (0.114)	0.172 (0.163)	0.014 (0.355)
Grade 7	-0.258** (0.102)	-0.240* (0.145)	-0.703** (0.356)	0.555*** (0.116)	0.615*** (0.166)	0.545 (0.387)
Grade 8	-0.146 (0.116)	-0.129 (0.163)	-0.062 (0.485)	0.875*** (0.130)	0.685*** (0.183)	1.297** (0.547)
	Panel B: Gains based on the Estimated Coefficient in Panel A					
Grades 5 to 6	-0.404*** (0.070)	-0.598*** (0.105)	-0.788*** (0.251)	-0.271*** (0.073)	-0.490*** (0.108)	-0.722*** (0.247)
Grades 6 to 7	-0.020 (0.069)	0.053 (0.103)	0.181 (0.248)	0.191*** (0.072)	0.443*** (0.109)	0.531** (0.254)
Grades 7 to 8	0.112 (0.087)	0.111 (0.126)	0.641 (0.412)	0.320*** (0.094)	0.070 (0.135)	0.752 (0.464)
No. of Students	1373	853	308	1373	853	307
Sample Size	38034	17193	3896	38010	17182	3891

Note: Robust standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence level respectively. Panel B reports differences between estimated coefficients in panel A. Significance levels are based on tests with the null hypothesis that estimated coefficients for consecutive grades are the same.