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The impact of charter schools on the efficiency of traditional public schools: Evidence from Michigan

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ABSTRACT

This paper examines the competitive effects of charter schools on the efficiency of traditional public schools. The analysis utilizes a statewide school-level longitudinal dataset of Michigan schools from 1994 to 2004. Fixed effect and two alternative estimation methods are employed. Overall, the results suggest that charter competition had a negative impact on student achievement and school efficiency in Michigan's traditional public schools. The effect is small or negligible in the short run, but becomes more substantial in the long run.

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1. Introduction

One of the central issues in the charter school debate is whether the competition induced by charter schools improves school efficiency. Recent research in this regard has focused on whether charter schools are more efficient than traditional public schools (TPS). However, the more important issue that remains unresolved is whether charter competition improves the efficiency of TPSs and thereby benefits the vast majority of students who remain in the traditional public school system.

School choice advocates argue that introducing school choice will result in TPSs working more efficiently. They suggest that TPSs both operate in a relatively monopolistic market and are overburdened by institutions of democratic governance that leave them vulnerable to the conflicting demands of multiple interest groups (Chubb & Moe, 1990). They have little incentive to improve the quality of education they provide their students or to increase the efficiency of their resource use. According to this view, the introduction of school choice helps to free schools from the constraints of both bureaucracy and monopoly, creating market incentives that induce TPSs to become more efficient.

Moreover, economists anticipate that the positive long-run effects on resource allocation, school quality, and even the existence of schools would be more substantial than the short-run effects (Hoxby, 2003a). In the short-run, an administrator who wants to raise school productivity has only limited options such as inducing the staff to work harder, getting rid of unproductive staff and programs, and allocating resources away from non-achievement oriented activities. However, in the long run, some general equilibrium mechanisms are available to an administrator. For instance, administrators can improve teacher quality through professional development, or propose higher salaries in order to attract high quality teachers, and thus draw people into teaching who would otherwise pursue other careers (Hoxby, 2003a).

Other scholars, however, argue that TPSs will not necessarily be more efficient when they face school choice competition. First, highly motivated students might be more active in choosing to attend choice schools; less motivated students would then be clustered in increasingly

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disadvantaged TPSs. These schools in turn would have difficulty responding to the competitive challenge because of negative peer effects over which school administrators have limited control. Second, losing students to choice schools will ordinarily decrease TPSs' educational revenue. Expenditure, however, cannot be so readily decreased. Losing students to competitors creates fiscal constraints for TPSs, which makes it harder for them to continue providing the same quality programs, let alone improve educational services. Since revenues may decline faster than costs in TPSs that lose students, TPSs may be compelled to cut programs, which could spur the loss of additional students and resources, and trigger a downward spiral (Arsen, Plank, & Sykes, 1999; Fiske & Ladd, 2000).

With the growth of school choice policies, better information on the merits of these contrasting viewpoints is clearly important, since – for the foreseeable future – the majority of students will still remain in the TPS system. However, the existing literature fails to provide consistent evidence on how school choice affects TPS efficiency. Researchers face two big empirical challenges in establishing the causal relationship between competition and student outcomes: choice schools are not randomly located and students systematically sort themselves between choice schools and TPSs, often in unobserved ways that affect school efficiency.

Using 11 years of school-level longitudinal data in Michigan, this paper examines the competitive effects of charter schools on the efficiency of TPSs. The analysis uses fixed effects and two alternative estimation methods that implicitly control for unobservable school characteristics, and explicitly control for changing student composition and other factors induced by the charter school policy. The analysis also separates the competition effect of charter schools from that of Michigan's inter-district school choice policy. My results show no positive competitive effect on student achievement in TPSs. Indeed, in areas with sustained, high-levels of charter school competition, I find a significant negative impact on TPS performance.

2. Literature review

There has been relatively little research on the impact of charter school competition on the efficiency of TPSs, because only recently have charter school policies become sufficiently widespread to elicit competitive response from TPSs. So far, studies of this issue have focused on states such as Florida, California, Arizona, Michigan, Texas, and North Carolina, where charter school laws have been in place long enough and charter school enrollments are large. Among these studies, the results are very mixed.

A number of methodological challenges must be addressed in the charter competition research. First, the location of charter schools is not randomly determined. It is reasonable to expect charter schools to locate in areas where students are not satisfied with the educational services they receive in TPSs, or in communities where parents tend to be more motivated and better informed. These characteristics of schools or communities are usually unobserved and will cause estimation bias if not controlled.[1] Second, the student self-selection problem may also confound estimation of the competitive effect on TPS efficiency. Students who move to charter schools probably differ systematically from the students who do not exercise their option to move. They may differ in past performance and family background, which are observable, as well as in motivation and innate ability, which are unobservable. As a result, charter schools may change the student composition of the TPSs from which they draw their students. For example, if charter schools tend to draw low-performing students, the average achievement level of students remaining in TPSs would automatically go up, even without any competitive effect.

Several strategies have emerged in the empirical literature to address these estimation issues. To address the problem of the endogeneity of charter location, researchers usually rely on estimation strategies such as fixed effects to eliminate unobserved heterogeneity. Alternatively, researchers could rely on instrumental variables (IV) estimators to obtain consistent estimation.[2] To correct for the student self-selection problem, scholars usually include lagged dependent variables to control for students' past performance, incorporate measures of schools' student composition as additional explanatory variables, or control for unobserved student heterogeneity when longitudinal student-level data are available.

Researchers have found charter competition to have a positive impact on TPS student achievement in Florida (Sass, 2006) and Texas (Bohte, 2004; Booker, Gilpatric, Gronberg, & Jansen, 2005), no effect in California (Buddin & Zimmer, 2005), and a negative effect in Ohio (Carr & Ritter, 2007). Each of these studies employed multiple measures of the degree of charter competition. The Florida and California studies employ student-level fixed effects regressions; Carr and Ritter's study and Bohte's study are based on school-level or district-level pooled time series regression analysis.

Two studies of North Carolina yielded different findings. Holmes, DeSimone, and Rupp (2003) reported that TPSs facing competition gained approximately one-quarter of the average yearly growth. Bifulco and Ladd (2006), however, found that competition from charter schools had no substantial impacts on TPS effectiveness. Bifulco and Ladd attributed the different results to their use of a student-level panel which allowed them to account fully for potential differences between students in TPSs located near charter schools and those in TPSs located elsewhere.

As in North Carolina, studies of Michigan have reported conflicting results. Bettinger (2005) estimated the short-run competitive effect of the first charter schools that opened in 1996, shortly after Michigan's charter school program was introduced. Bettinger employed a difference-in-difference strategy and introduced an IV to correct for bias from the endogeneity of charter location. The study

[1] Glomm, Harris, and Lo (2005) find that the location of charter schools in Michigan is related to measures of public school quality.

[2] Appropriate IVs should be correlated with where charter schools choose to locate, but have no impact on unexplained student outcomes. Empirically, however, IVs of this kind are hard to find in charter school research.

found that charter schools had little or no effect on test scores in neighboring public schools. In contrast, a study by Hoxby (2003b) reached different conclusions. Applying a detrended difference-in-difference strategy to control for each school's initial productivity and trend from 1992–1993 to 1999–2000, Hoxby found that TPSs in Michigan raised their productivity and achievement once charter school enrollment reached at least 6% of district enrollment. In the same study, Hoxby also found similar positive charter school competitive effects in Arizona. Hoxby's estimates, however, did not control for changes in student mix or other school characteristics.

As this brief review has shown, research to date has not yielded a clear or consistent set of findings on the impact of charter schools on traditional public schools. This reflects in part the heterogeneity in charter school programs themselves: It is reasonable to expect that any competitive effects would depend on the design of the charter school program and the state and local contexts where they are implemented. Different estimation techniques and research methodologies may also explain these conflicting results, including disparate results in the same state. First, the measure of competition from charter schools varies across studies. Some researchers use the number of charter schools within a given radius of public schools to measure the intensity of competition (e.g., Bettinger, 2005; Bifulco & Ladd, 2006; Sass, 2006). Others use the distance of a public school from a charter school to measure competition (e.g., Bifulco & Ladd, 2006; Holmes et al., 2003). Still others measure competition by the percentage of students who have exited to charter schools, or identify a certain percent of a school district's enrollment in charter schools as the threshold of competition (e.g., Booker et al., 2005; Hoxby, 2003b). For checks of robustness, some researchers evaluate several different measures of the degree of competition (e.g., Bifulco et al., 2006; Sass, 2006). Yet a review of these studies indicates no clear relationship between findings and measures of charter competition, and there is no consensus about which measure is better than the others.

A related issue is that the unit of analysis varies across studies. It is reasonable to take schools or schools districts rather than individual students as the unit of analysis, since schools or districts are the decision-making organizations that allocate resources to different programs and to different groups of students so as to collectively respond to charter competition. Nevertheless, researchers increasingly use students as the unit of analysis when student-level data are available, because students who choose to attend charter schools may differ systematically from students remaining in TPSs in unobserved ways. Controlling for student fixed effects can reduce these sources of heterogeneity bias. While there are pros and cons in the selection of the unit of analysis and the measure of competition, there is no systematic relationship between either of these and the estimated results of the effects of competition.

3. School choice context in Michigan

In 1993, Michigan became the eighth state to adopt a charter school law. A charter school, officially designated a public school academy (PSA) in Michigan, is a state-supported public school that operates independently under a charter granted by an authorizing body. In Michigan, PSAs can be chartered by local school districts, intermediate school districts, the state board of education or the governing boards of public community colleges or universities. Charter schools have no geographic boundaries. Students are free to choose to go to any charter school in the state, on a space available basis.

Originally, no limit was imposed on the number of charters that could be issued by any of the authorizing boards. However, in 1996, following a proliferation of charters issued by the board of Central Michigan University, the state legislature imposed a cap on the total number of schools that may be chartered by the Michigan's 15 public universities. This cap of 150 schools has limited new school development since 2000. However, there is no cap on the number of schools chartered by other organizations, and the number of charter schools has grown steadily in Michigan over the past decade. The first charter schools opened in Detroit in 1994; 10 years later Michigan had 226 charter schools enrolling about 92,000 students (or 5% of the state's public school population). In 2005, Michigan's charter enrollment was the third largest in the nation after California and Florida.

Michigan's school finance system, commonly known as Proposal A, greatly facilitated the charter school program's development. Approved in 1994, Proposal A shifted the responsibility for funding school current operations from local districts to the state. Besides state and federal categorical aid, school districts receive almost all their operational revenues from the state in the form of a per-pupil foundation grant, which was approximately $6875 in 2006.[3] That money goes directly to the school district that the students attend. Under Proposal A, local voters can no longer increase local taxes to support school operations.[4] Charter schools receive a per-pupil foundation grant equal to that of the district in which the school is located.[5] Thus, the amount of operating revenue that districts and charter schools receive depends almost exclusively on the number of students they enroll. Essentially the only way schools can increase their revenue is to attract more students. In this sense, the school finance system in Michigan creates the ideal competitive market for schooling and makes Michigan an especially important case for studying the effects of charter schools on traditional public schools.

In addition to the charter school program, in 1996, the Michigan Legislature created an inter-district choice pro-

[3] A small set of hold-harmless districts, whose foundation in 1994–1995 exceeded $6500, are eligible to levy additional local property taxes up to a cap to sustain funding above the state basic foundation allowance.

[4] State law permits local districts within an Intermediate School District (ISD) to join together to seek voter approval of up to two mills. ISD enhancement millages are a form of property tax base sharing and must be approved by a majority of the voters in the ISD with the revenues shared among districts on an equal per-pupil basis (Arsen & Plank, 2003). Since 1997, only a few ISDs have won approval for enhancement millages.

[5] However, there is a cap on the PSA foundation allowance, which limits their revenue below that of TPSs in the highest revenue school districts (Addonizio, Mills, & Kearney, 2000). In addition, charter schools receive federal and state categorical funding on the same basis as school districts.

gram that allows students to choose public schools located outside their home districts. School districts can determine whether or not to accept nonresident students. However, they cannot prohibit students who live within their boundaries from attending public schools in another district that admits them. As of 2004, about half of Michigan's 555 local districts enrolled nonresident students under the inter-district choice program. The charter school and inter-district choice programs are designed so differently that they are likely to have a different impact on TPSs. In this paper, the measures of the intensity of inter-district choice are included as control variables to separate the competitive effect of charter schools from that of inter-district choice.

4. Research questions

This paper aims to address some of the limitations of past research and investigate the relationship between charter competition and TPS efficiency. Specifically, I ask two questions: (1) how has competition from charter schools influenced efficiency in TPSs? and (2) does the competition generate different impacts on TPS efficiency in the short-run and the long-run?

Like Hoxby (2003b) and Bettinger (2005), my analysis focuses on Michigan's charter school program. However, my research differs from both studies in several respects. First, the availability of more recent data allows me to evaluate both the short-run and long-run effects of the charter school policy. Second, more detailed school-level data enable me to capture other systematic changes induced by charter schools, including changes in student composition and school expenditure. Third, my models explicitly control for the competition from Michigan's other choice program – inter-district choice – which might confound the effect of charter competition if not controlled. Fourth, I measure the charter competition confronted by each district as the percentage of resident students who have transferred to charter schools, instead of charter school enrollment as a percentage of the total enrollment in the charter host district. I will later elaborate on why the difference between these two measures is important.

5. Data and methodology

5.1. Data sources

This analysis utilizes a statewide school-level panel dataset of Michigan schools from 1994 to 2004. The data were assembled from three main sources: the Michigan Department of Education (MDE), the State of Michigan's Center for Educational Performance and Information, and Common Core Data from the National Center of Educational Statistics. The merged dataset includes information by school for school choice enrollment, student demographics, school finance, and other school level factors over the 11 years. Michigan's Single Record Student Database (SRSD) for 2002–2003 and 2003–2004 were used in constructing the measure of charter competition.

Data on student achievement – the scale scores and the percentages of students attaining satisfactory performance levels on the Michigan Educational Assessment Program (MEAP) tests – come from the MDE's Office of School Assessment and Accountability. These include reading and math scores in the 4th and 7th grades. The 7th grade math data are only available from 1994 to 2000 because the test was no longer administered after 2000. In addition, according to MDE officials, the reading test was significantly changed in 2003 in all aspects including the test design, subject coverage, and content standards, so it is not possible to validly compare the scores before and after 2003. Therefore, reading data in 2003 and 2004 are excluded in the estimates. Since Michigan students were generally not tested annually in the same subjects during the years included in this study, student-level longitudinal achievement data are not available.

5.2. Measure of competition

Competition from charter schools is measured at the district level since school-level charter dis-enrollment data are not available. The loss of students to charter schools influences total district revenues; the districts then decide the resource allocation among individual schools. Thus, in the first instance, it is the school district that experiences and responds to competitive pressure from charter schools.

Charter competition is measured through two dimensions: the magnitude and the duration of the competition. The indicator of the magnitude of charter competition used here improves upon that introduced by Hoxby (2003b). She defined a dummy variable measuring "strong charter school competition." The variable takes a value of one if the enrollment in charter schools in the district reached 6% of the district's enrollment. Thus, her measure assumes that students live in the district where their charter school is located. This assumption does not always hold, however, in Michigan's case. In fact, more than one-third of Michigan's charter schools draw the majority of their students from districts other than the district in which the charter school is located.[6] Accordingly, I defined charter competition faced by a district as the percentage of resident students in a district who have transferred out of a TPS and into a charter school.[7] It is impossible to identify

[6] Because charter schools often locate just outside an urban district from which they are drawing their students, my measure generates a very different list of districts facing charter competition than those created under the presumption that students come from the district where the charter school is located. See Hoxby (2003b) for her list of districts facing high charter competition (Table 8.10, on p. 326). Even using Hoxby's measure, however, I was unable to replicate her list of districts affected by charter competition. In particular, some central cities with more than 6 percent charter school enrollment in 2000, such as Flint, Pontiac, Saginaw, and Benton Harbor, are not in her list. Using Hoxby's measure, my data show that each of the districts mentioned above had charter enrollment in 2000 exceeding 6 percent of district enrollment.

[7] This includes all charter schools. Although this study examines competitive effect at elementary and middle school levels, enrollment in charter high schools is included for two reasons. First, charter school enrollment in Michigan is concentrated in grades K-8. High school enrollment (grades 9–12) represented only 13% of all charter enrollment in 2004. Including or excluding high school enrollment should not make a big difference. Secondly, charter competition is measured at district level. Any

the actual percentage of charter school students from each sending district before 2002 as student-level data were unavailable. I assume, therefore, that the percentage of students from each sending district in a given charter school for 1994–2002 is the same as in 2003.[8] Based on the actual individual enrollment information in the 2003 SRSD data, I then imputed the percentage of students that each district lost to charter schools for 1994–2002.[9]

The degree of competition can be measured as either a continuous or dummy variable. Hoxby (2003b) and Bettinger (2005) use a dummy variable which takes the value of 1 if the percentage of charter enrollment reaches 6%, and 0 otherwise. As Hoxby (2003b) argues, the impact of competition should not be linear, but negligible at low levels and becoming more observable when the share of charter enrollment reaches a threshold. I follow their method in my analysis. Nevertheless, a continuous charter competition variable, constructed as the log of the exact percentage of students transferring to charter schools, was used to check robustness.

To capture the second dimension of charter competition, its duration, I created three dummy variables that distinguish the effect of charter competition in the short-run, medium-run, and long-run. For instance, if a district lost more than 6% of its students to charter schools for no more than 3 years, I identified the charter competition as short-run. Likewise, the loss of more than 6% of students for 4–5 years is defined as medium-run competition, and for longer than 5 years as long-run competition.

Finally, a vector of dummy variables measuring both the magnitude and the duration of charter competition is obtained by interacting the dummy variable reflecting the level of competition (whether more than 6% of students transferred to charter schools) with the three duration dummy variables.

5.3. Estimation strategies

Several approaches are involved in estimating the charter competitive effect. First, I utilize pooled OLS to estimate how charter competition relates to student achievement. Then I employ fixed effects (FE) estimators and several other estimation techniques to address the potential bias caused by the endogeneity of charter competition.

In general, an education production function is expressed as

$$Y_{it} = \boldsymbol{CS}_{it}\boldsymbol{B}_1 + \boldsymbol{SCH}_{it}\boldsymbol{B}_2 + \boldsymbol{IC}_{it}\boldsymbol{B}_3 + I_t\delta + V_{it} \quad (1)$$

where Y_{it} is the average student achievement of school i in year t, specifically in this study, the standardized scale scores of the MEAP tests. The test scores measure school effectiveness when other educational inputs are *not* controlled. After controlling inputs such as expenditure and student demographics, the test scores measure school efficiency or productivity which reflects achievement per dollar spent. The percentages of students passing the MEAP test at a satisfactory level were also used as a dependent variable to check robustness.

The variables of interest in this analysis are included in $\boldsymbol{CS}_{it}$, a vector of dummy variables that reflects both the magnitude and the duration of charter competition of school i at time t. As noted, although the unit of analysis is the school, the competition measure, $\boldsymbol{CS}_{it}$, is a district-level measure. To check robustness, I also tried the continuous charter competition measure in the estimation. $\boldsymbol{SCH}_{it}$ is a vector of characteristics of school i at time t, including the percentage of students eligible for the free/reduced price lunch (FRL) program, the percentage of students who are minority, district size, and per-pupil operational expenditure in logarithmic form to impose a diminishing effect of spending on performance. $\boldsymbol{IC}_{it}$ is a vector of two variables reflecting the percentage of students transferring out of a district and the percentage of nonresident students transferring in through the inter-district choice program. A set of year dummies, I_t, is also included to capture any systematic influence not accounted for by the observable inputs that vary over time but are common to all schools. V_{it} is the unobserved error.

First, I estimate Eq. (1) with OLS by pooling data across schools and over years. However, in order to produce a consistent estimator of the competitive effect, pooled OLS assumes all school-level variables not controlled in the model are uncorrelated with charter competition, which is unlikely to be true in this analysis, because the location of charter schools might be influenced by unobserved features of TPSs. To address this limitation of the pooled OLS, I decompose the error term V_{it} in Eq. (1) into a school fixed effect and an idiosyncratic error that changes over time (Wooldridge, 2000). The same set of school factors is included to capture possible changes in school factors. The equation becomes

$$Y_{it} = \boldsymbol{CS}_{it}\,\boldsymbol{B}_1 + \boldsymbol{SCH}_{it}\boldsymbol{B}_2 + \boldsymbol{IC}_{it}\,\boldsymbol{B}_3 + It\delta + \theta_i + u_{it} \quad (2)$$

where θ_i is an unobserved school fixed effect or heterogeneity that picks up all the unobserved characteristics of a school that are stable over time, including historical reasons that influence charter location. u_{it} is the idiosyncratic error term that changes across time for each school.

I estimate Eq. (2) through FE transformation with standard errors robust both to serial correlation and heteroskedasticity. Since the competition is measured at the district level, the robust standard errors were clustered by district. FE transformation can readily eliminate the unobserved school heterogeneity (θ_i) that affects student achievement, and allows for arbitrary correlation between

enrollment loss due to the departure of students to charter schools will be experienced initially in a decline in total revenues available to local districts which in turn must adjust the allocation of revenues to schools. Charter competition at the high school level is therefore likely to have some fiscal impact at K-8 level.

[8] The percentages of students drawn from each sending district in a given charter school between 2003 and 2004 are highly correlated, with a correlation coefficient of 0.98.

[9] I also constructed the same measure of charter school competition as Hoxby used in her study. The correlation between the two measures is 0.57. Estimates based on this alternative competition measure generated similar results but smaller in magnitude. A possible reason for this is that the alternative measure underestimates charter competition in some districts and overestimates it in other districts. For example, many charter schools draw students from central cities, even though they are located in surrounding suburban districts. As a result, the estimation of the alternative measure is biased toward 0.

θ_i and $\boldsymbol{CS}_{it}$, which means that the location of charter schools is allowed to be related to historical differences among schools. Consistency of the FE estimator requires that charter competition is strictly exogenous after accounting for the school heterogeneity (which means charter competition, $\boldsymbol{CS}_{it}$, must be uncorrelated with the idiosyncratic errors, u_{ir}, in all time periods r). However, how schools respond to charter competition in the past might influence the magnitude of charter competition in the future. If this is the case, the strict exogeneity assumptions will be violated, and the general FE estimator will be biased.

If the strict exogeneity assumption fails, the bias of the FE estimator is of order $1/T$ and the magnitude of bias is c/T, where T is the sum of t. This means that even though we do not know the value of c, the magnitude of the bias of the FE estimator decreases substantially for large T, which is 11 in this study. For robustness checks on the consistency of the FE estimator, I also estimated Eq. (2) through a first-differenced (FD) estimator, where I first differenced the equation across years to remove θ_i and estimated it by pooled OLS with robust standard errors. If the strict exogeneity assumption fails, the magnitude of the bias of the FD estimator is c, and it remains essentially the same as the length of time, T, grows. Although when the strict exogeneity assumption fails both the FE and FD estimates are biased, it is very useful to compare the two to gain a sense of whether the estimates are biased, and the direction and magnitude of any bias (Wooldridge, 2000).

In the FE and FD estimations, the unobserved effect is defined to have the same partial effect on performance rates in all the time periods. This assumption might be too strong for this study, because 11 years is a relatively long time. A random trend model allows us to control for an additional source of heterogeneity. In addition to the level effect, θ_i, the random trend model allows each school to have its own time trend, g_{it} (Wooldridge, 2002), which can be written as

$$Y_{it} = \boldsymbol{CS}_{it}\,\boldsymbol{B}_1 + \boldsymbol{SCH}_{it}\boldsymbol{B}_2 + \boldsymbol{IC}_{it}\,\boldsymbol{B}_3 + It\delta + \theta_i + g_{it} + u_{it} \qquad (3)$$

In Eq. (3), charter competition is not just a function of schools' initial historical factors, but also a function of how quickly a district responds to the charter competition. For instance, if a TPS quickly responds to charter competition and improves its student achievement by innovations in instruction or governance, the random trend model allows the time trend of this school to be different from TPSs having no or little response when facing charter competition. There are many ways to estimate the random trend model. In this paper, I estimated it by first differencing the equation to eliminate θ_i and then applying the FE transformation to the first differenced equation, which eliminates the school-specific trend, g_{it}.

In addition to the heterogeneity bias, the second source of potential bias arises if charter competition is contemporaneously correlated with unobserved time-varying, idiosyncratic variables that affect student achievement. For example, parental motivation or other factors that might be correlated with charter competition are still in the time-varying error term, which could cause charter competition to be endogenous. Under this circumstance, IV estimation would be ideal for obtaining consistent estimates. In this study, however, this is less a concern, because I am able to control for other school variables such as student composition, expenditure, and class size. By explicitly controlling for these variables, there should be much less variation left over in the time-varying error term.[10]

6. Findings

6.1. Descriptive statistics

Table 1 provides information on charter competition in Michigan from 1994 to 2004. The percentage of charter school enrollment statewide increased almost every year. In 2004, it reached 4.2% of all public school students. Although the first charter schools in Michigan were founded in 1994, no TPS experienced strong charter competition before 1996. By 2004, about 370, or 14% of all TPSs in Michigan had experienced long-run charter competition and an additional 13% had experienced only short- or medium-run charter competition. Table 2 further shows that most TPSs facing strong charter competition are located in urban school districts. In 2004, about 79% of all TPSs in central cities experienced significant charter competition, and the majority of these schools had faced long-run charter competition for more than 5 years.

Table 3 presents the percentages of students passing the MEAP test at a satisfactory level for both math and reading in 4th and 7th grades. Throughout the 11 years, TPSs facing significant charter competition had consistently lower satisfactory scores than the schools facing no substantial charter competition, with only a few exceptions in the earlier years. The statewide mean satisfactory rates fluctuated around an increasing trend across the years, indicating that standardized scale scores are more stable measures of student outcome and suggesting the necessity of including year dummies in the analysis to account for the statewide changes in the tests. In addition, Table 3 shows that TPSs facing charter competition had substantially more low-income and black students than schools facing no charter competition. This is consistent with the fact that Michigan charter schools are more likely to be located in or adjacent to central cities and draw central cities students who are more likely to be poor students of color.

Table 4 displays the descriptive information of the variables used in the models, along with their means and standard deviations. As with the measures of charter competition, inter-district choice is a district-level measure. On average, districts gained 1.38% students and lost 1.43% students through inter-district choice. Since the percentages are not weighted by district size, the difference between the two indicates that the districts gaining or losing stu-

[10] Moreover, caution is warranted in using the IV estimation because truly external IVs are very hard to find in charter school research. Use of weak IVs that are not strictly exogenous tends to inflate the bias. More often than not, slight correlation between the IVs and the variables that they are instrumented for (charter competition in this case) could cause larger bias than estimators using no IVs (Wooldridge, 2002). From a policy perspective, we need to be cautious about the potential inflation of bias and put more weight on conventional methods such as FE or FD estimations, especially when their results are consistent.

Table 1
TPSs facing strong charter competition, by year and duration.

Year	% of state enrollment in charter schools	Number of schools experiencing strong charter competition			Total
		Short-run	Medium-run	Long-run	
1994	0.02	0	0	0	2497
1995	0.03	0	0	0	2502
1996	0.33	19	0	0	2497
1997	0.86	94	0	0	2499
1998	1.39	198	0	0	2505
1999	2.19	488	11	0	2508
2000	3.09	541	74	0	2507
2001	3.77	640	168	11	2729
2002	3.92	217	372	66	2552
2003	3.67	158	375	157	2712
2004	4.24	199	135	369	2685

Table 2
TPSs facing strong charter competition in 2004, by community type.

Community type	Number of schools experiencing charter competition			Universe of schools	% of schools experiencing strong competition
	Short-run	Medium-run	Long-run		
Urban	67	96	306	595	78.8
Suburban	70	31	31	1364	9.7
Rural	62	8	8	726	10.7

Table 3
Summary statistics of satisfactory rates and other student characteristics, by year, charter competition, and subjects.

	4th grade math			4th grade reading		
	No charter competition	Strong charter competition	Difference	No charter competition	Strong charter competition	Difference
1994	48.5	–	–	43.0	–	–
1995	61.2	–	–	42.9	–	–
1996	63.1	62.1	1.0	49.7	51.7	−2.0
1997	60.9	51.2	9.7	49.0	38.2	10.8
1998	75.1	62.6	12.5	59.1	45.7	13.4
1999	75.2	61.5	13.7	62.5	48.6	13.9
2000	79.9	64.7	15.2	61.7	49.6	12.2
2001	78.1	59.2	19.0	66.0	48.0	17.9
2002	70.3	49.4	20.8	63.1	39.2	23.9
2003	70.5	49.4	21.0	–	–	–
2004	77.7	59.4	18.4	–	–	–
	7th grade math			**7th grade reading**		
	No charter competition	Strong charter competition	Difference	No charter competition	Strong charter competition	Difference
1994	40.9	–	–	38.5	–	–
1995	48.3	–	–	34.8	–	–
1996	54.1	63.0	−8.8	41.6	52.6	−11.0
1997	50.9	45.3	5.6	39.3	33.4	5.9
1998	61.2	51.3	10.0	47.9	42.2	5.7
1999	65.8	47.6	18.2	54.7	41.5	13.2
2000	66.8	44.3	22.6	50.1	37.2	12.9
2001	–	–	–	61.3	43.5	17.8
2002	–	–	–	55.3	31.7	23.6
	% FRL			**% Black**		
	No charter competition	Strong charter competition	Difference	No charter competition	Strong charter competition	Difference
1994	26.0	–	–	14.8	–	–
1995	28.5	–	–	15.9	–	–
1996	28.2	26.5	1.6	16.5	15.7	0.8
1997	28.3	36.3	−8.0	16.7	18.2	−1.5
1998	27.6	46.6	−19.0	16.0	33.1	−17.0
1999	22.6	54.5	−31.9	8.0	57.5	−49.5
2000	26.7	67.7	−40.9	5.4	60.1	−54.7
2001	26.4	55.3	−28.8	5.9	53.7	−47.8
2002	29.3	66.0	−36.8	6.0	60.4	−54.5
2003	30.3	64.4	−34.1	6.7	59.0	−52.2
2004	31.4	66.3	−34.9	6.9	56.3	−49.3

Note: 7th graders were no longer tested in math since 2001.

Table 4
Description of explanatory variables.

Variable	Description	# of obs.	Mean	Std. dev.	Min	Max
Inter-district choice						
Transfer-in	% students transferring in	28,043	1.38	4.13	0	100.00
Transfer-out	% students transferring out	28,043	1.44	3.98	0	188.89
Log(per-pupil exp)	Per-pupil expenditure in logarithm form	28,184	8.90	0.17	8.22	10.88
Log(enroll)	Log of district enrollment	26,909	6.05	0.65	0.69	11.93
% FRL	% students eligible for free lunch	26,704	32.30	26.10	0	99.69
% Black	% black students	27,027	17.38	31.10	0	100.00
% Asian	% Asian students	27,027	1.69	3.31	0	85.23
% Hispanic	% Hispanic students	27,027	3.42	7.27	0	89.53

dents are not the same. The means are calculated across all years, and the transfers of students were much bigger in recent years. By 2004, about 3% of all public students participated in inter-district choice. Statewide, students who are eligible for the FRL program account for 32% of all students across years. This number increased every year. In 2004, about 40% of students statewide were eligible for FRL. Black students comprise the largest minority group in Michigan public schools. Hispanic and Asian students combined account only for about 5% of all students. Statewide, the percentages of minority students increased 6% points between 1994 and 2004.

6.2. Pooled OLS

First, I pooled the data across years and estimated the standardized scale scores as a function of charter competition and other controls by OLS. A set of year dummies was added to allow for secular changes in student performance over time. Table 5 reports the results for both math and reading in 4th and 7th grades. For each subject and grade, the first column shows results with no other control variables, while the following column shows the results of the model including the full set of control variables. Heteroskedasticity-robust standard errors clustered by districts are reported in parentheses.

Looking at the pooled OLS results with no controls, it is clear that there is a strong negative association between charter competition and test scores for both subjects in both grades. For example, the results in column (1) show that, once a school faces strong charter competition, its 4th grade average math score decreases about 0.67 standard deviations in the short-run. If the strong charter competition persists, the test scores drop further than in

Table 5
Pooled OLS results: the impact of charter competition on standardized test scores.

	4th grade math		4th grade reading		7th grade math		7th grade reading	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Charter competition								
Short-run	−0.67**	−0.16*	−0.50**	−0.13*	−0.85**	−0.05	−0.49**	−0.06
	(0.083)	(0.065)	(0.057)	(0.062)	(0.095)	(0.058)	(0.057)	(0.046)
Medium-run	−0.79**	−0.18	−0.65**	−0.23	−0.22	−0.04	−0.61**	−0.22
	(0.132)	(0.157)	(0.113)	(0.17)	(0.313)	(0.257)	(0.147)	(0.171)
Long-run	−.74**	−0.15	−0.35**	−0.12	–	–	−0.23	−0.02
	(0.119)	(0.103)	(0.133)	(0.086)			(0.192)	(0.149)
Inter-district choice								
Transfer-in		−0.01		−0.01		−0.02		0.001
		(0.004)		(0.003)		(0.011)		(0.005)
Transfer-out		0.002		0.003		0.002		0.004
		(0.005)		(0.004)		(0.018)		(0.006)
Log(per-pupil exp)		0.58**		0.36**		0.63**		0.39**
		(0.115)		(0.086)		(0.209)		(0.107)
Log(enroll)		−0.01		0.001		0.10*		0.02
		(0.03)		(0.021)		(0.045)		(0.025)
% FRL		−0.01**		−0.01**		−0.01**		−0.01**
		(0.001)		(0.001)		(0.001)		(0.001)
% Black		−0.003*		0.001		−0.01**		−0.004*
		(0.001)		(0.002)		(0.002)		(0.002)
% Asian		0.03**		0.01**		0.07**		0.03**
		(0.006)		(0.004)		(0.021)		(0.006)
% Hispanic		−0.01**		−0.01**		−0.02**		−0.01**
		(0.002)		(0.002)		(0.003)		(0.003)
Obs.	20,369	19,611	16,669	16,143	5216	4980	6673	6351
R^2	0.31	0.51	0.18	0.42	0.15	0.46	0.18	0.42

Note: The heteroskedasticity-robust standard errors are clustered by district and included in the parentheses. Year dummies were included in the estimations but the results are not reported.

* Significant at 5%.

** Significant at 1%.

Table 6
Fixed effects, first differencing, and random trend estimations of the impact of charter competition on standardized test scores.

	(1) Fixed effects (FE)	(2) First differencing (FD)	(3) Random trend model (FD + FE)
4th math			
Short-run	−0.10	−0.12	−0.12
	(0.080)	(0.070)	(0.069)
Medium-run	−0.23	−0.18*	−0.20*
	(0.143)	(0.086)	(0.091)
Long-run	−0.25*	−0.17*	−0.18
	(0.099)	(0.087)	(0.101)
Obs.	19,611	17,460	17,460
R^2	0.49	0.13	0.13
4th reading			
Short-run	−0.19*	−0.17**	−0.17**
	(0.085)	(0.061)	(0.059)
Medium-run	−0.40	−0.31**	−0.29**
	(0.205)	(0.112)	(0.107)
Long-run	−0.34**	−0.49**	−0.50**
	(0.130)	(0.111)	(0.117)
Obs.	16,143	14,063	14,063
R^2	0.30	0.10	0.10
7th math			
Short-run	−0.15**	−0.12*	−0.13*
	(0.042)	(0.051)	(0.063)
Medium-run	−0.01	0.03	0.02
	(0.083)	(0.115)	(0.148)
Long-run	–	–	–
Obs.	4980	4133	4133
R^2	0.37	0.13	0.14
7th reading			
Short-run	−0.16**	−0.10*	−0.10
	(0.044)	(0.051)	(0.053)
Medium-run	−0.44**	−0.32**	−0.33*
	(0.147)	(0.122)	(0.131)
Long-run	−0.31**	−0.46**	−0.50**
	(0.12)	(0.130)	(0.142)
Obs.	6351	5465	5465
R^2	0.33	0.14	0.15

The *R*-squares are net of school fixed effects. The standard errors in parentheses are clustered by district and robust to both heteroskedasticity and serial correlation. The full set of control variables were included in the estimations but not reported in the table. The long-run effect on 7th grade math is not estimated because the data are unavailable after 2000. See Table 5 for other notes.

schools facing no substantial charter competition. The negative association between charter competition and student achievement becomes much smaller in magnitude when the full set of control variables is included. For instance, column (2) shows that 4th grade math scores decrease only 0.16 standard deviations under charter competition in the short-run, after controlling for school characteristics. In addition, the effect is no longer significant in the medium- and long-run. This is consistent with the fact that charter schools tend to locate near schools with characteristics associated with low student performance. Once student demographic and financial variables are controlled, the effect of the charter school competition becomes much smaller. The subsequent columns show similar patterns for 4th grade reading and 7th grade math and reading.

Neither the transfer-in nor transfer-out of students through inter-district choice seems to have any impact on student achievement in the pooled OLS estimations. Educational expenditure is positively associated with student achievement across different specifications. Results in column (2) show that a 10% increase in operational expenditure per pupil increases the average test score by 0.06 standard deviations. The estimated effects of other control variables are also consistent with expectations. High concentrations of low-income, Black, and Hispanic students are associated with lower test scores. However, high percentages of Asian students are associated with higher test scores in each subject in both grades. District size does not seem to be related to test scores.[11]

Taking the results at face value, the estimates suggest that charter schools have a negative competitive effect on student achievement. It also implies a negative competitive effect on school efficiency, since spending and other inputs are controlled for in the models. However, although pooled OLS estimation explicitly controls several school factors, it cannot remove the unobserved school effects. If the unobserved school effects are correlated with the

[11] When charter competition is measured as a continuous variable (the log of the percentage of a district's students transferring to charter schools) and the dependent variables are changed to satisfactory rates, similar results were found: charter competition is negatively correlated with student achievement (See Table A.1).

degree of charter competition, the pooled OLS estimates would be biased. Thus, I employ FE and other methods to address this possibility.

6.3. Fixed effect Estimations and potential sources of bias

Results in Table 6 show the impact of charter competition on math and reading test scores in 4th and 7th grades derived from FE estimates, followed by FD and random trend models. Column (1) of Table 6 contains the results for the FE estimates. For 4th grade math, the effect of charter competition in the short-run is negative but insignificant. The effect becomes larger in the medium-run and significant in the long-run: 4th grade math test scores in a school facing strong charter competition for more than 5 years are estimated to decrease by 0.25 standard deviations.

The results for FD estimates are presented in column (2) of Table 6. The sample size is smaller for the FD estimator because one year of data is lost with the first differencing. The estimated charter competitive effect is insignificant in the short-run but becomes larger and significant in the medium- and long-run, indicating persistent charter competition decreases 4th grade math scores by 0.18 standard deviations, fairly consistent with the FE estimate.

A random trend model is also estimated to allow each school to have its own time trend. As column (3) in Table 6 shows, the results are consistent with the FE and FD estimators, except that the estimated long-run effect is only marginally significant at the 10% level. This further indicates that, after controlling for unobserved school heterogeneity and other variables, the potential problem associated with what remains in the idiosyncratic error is negligible.

For 4th grade reading, the FE estimates show that charter competition has a modest negative impact on reading in the short-run, lowering the test scores by 0.19 standard deviations. The magnitude of the impact becomes larger in the medium-run and long-run, where charter competition decreases reading scores by about 0.34 standard deviations. The FD and random trend models show parallel results with the long-run effect as large as 0.5 standard deviations.

Charter competition seems to have modest negative effects on 7th grade math in TPSs in the short-run and no effect in the medium-run. The long-run effects are not estimated because 7th grade math was no longer tested after 2000. The last panel of Table 6 shows the effect of charter competition on 7th grade reading achievement. FE estimates in column (1) show that charter competition has a modest negative effect on 7th grade reading in TPSs in the short-run. This adverse effect grows to more than 0.3 standard deviations in the medium-run and the long-run. Again, as shown in columns (2) and (3), the FD and random trend models generate similar results, with the long-run negative effect of charter competition up to 0.5 standard deviations.[12]

7. Discussion and conclusion

My analysis suggests that overall charter school competition has had a negative impact on student achievement in Michigan's traditional public schools. The effect is small or negligible in the short-run, but becomes more substantial in the medium- and long-run. The negative effect of charter competition is consistent for both math and reading tests in both 4th and 7th grades and robust across a range of econometric models and estimations. In the long run, for schools in districts where charter schools have drawn away a significant share of students, the estimated charter competition decreases their test scores by 0.2 standard deviations in math and 0.4–0.5 standard deviations in reading. In addition, the competitive effect varies across communities. In general, the results do not support the positive competitive effect hypothesis, which holds that competition from charter schools spurs regular public schools to improve their efficiency. They also question the claim that charter competition benefits traditional public schools more substantially in the long run.

In Michigan, about half of the charter schools are located in Detroit and other central cities, attracting students from these areas and nearby low-income suburbs. Many traditional public schools in urban districts have experienced great charter competition and faced acute financial pressure due to the loss of students to charter schools. For example, about 30,000 students who live in Detroit attended charter schools in 2004. Together with 5000 students attending suburban schools through inter-district choice, Detroit Public Schools has lost about one fifth of its students, amounting to an annual loss of about $260 million educational revenue through both choice programs. Other central cities in Michigan, such as Lansing, Flint, Pontiac, and Benton Harbor have experienced similar proportionate losses. By contrast, the vast majority schools in rural and suburban areas face little competition from charter schools. In other words, the analysis in this paper largely reflects an urban phenomenon in Michigan. Charter competition appears to reinforce a vicious cycle of enrollment loss, revenue decline, program cuts, lower educational quality, and further enrollment loss in these districts (Arsen et al., 1999).

My findings are largely consistent with Bettinger's (2005) finding that through 1999, charter schools had no or small effects on the test scores of students in TPSs. His Michigan data pertained to a period in which only the short-run effect of charter competition could be captured. However, my results differ from an early study of Michigan's charter schools which suggested that charter competition improved student achievement in TPSs (Hoxby's, 2003b). There are several possible reasons for the difference in our findings, including the time period covered, different estimation methodologies, different controls, and different measures of competition. First, my study draws on 4 more years of data, enabling me to distinguish short

[12] To check for robustness, Tables in the Appendices show the results using alternative measures. In Table A.2, the dependent variables are satisfactory rates. In Table A.3, charter competition is measured continuously. In general, the results are similar to the results shown in Table 6. However, in Table A.3, some results become insignificant, especially the ones in the random trend models. This might imply that the impact of charter competition on TPSs is not continuous and the dummy variables might be a better way to capture this.

and long-run competitive effects of charter schools. Second, in addition to controlling for charter competition, my estimates control for changes in school characteristics across time, such as student racial and SES composition and school expenditures. I also control for student flows associated with Michigan's sizable inter-district choice program, introduced simultaneously with its charter school program. Finally, my access to Michigan's Single Record Student Database allowed me to construct a more precise measure of the competition faced by traditional public schools that was not available to previous researchers using district-level data. Since charter schools often locate just outside urban districts from which they recruit students, previous measures may have under-estimated the competition experienced by urban districts and over-estimated competition in the suburban areas where charters were physically located.

One potential limitation of the current paper and the previous Michigan studies is that the school-level data may not fully account for the student self-selection problem. Despite explicitly controlling for observable changes in school student composition in this study, school-level data cannot control for the possibility of changing unobservable characteristics of the student population within schools. The negative charter effects found in this study might therefore conflate some student sorting effects resulting from charter schools with their competition effects.

While this study finds significant negative competitive effects in Michigan, studies in other states, as noted, have found charter schools to have no effect (North Carolina and California) or slight positive effects (Florida and Texas) on student achievement in TPSs. Besides the methodological issues noted above, the difference in measured effects of charter competition is undoubtedly sensitive to important features of charter school policy as well as the local contexts in which the policies are implemented (Arsen & Ni, 2008; Goldhaber, Guin, Henig, Hess, & Weiss, 2005). First, the population change in a state will greatly influence the competitive pressures of charter schools. In states with growing enrollment, charter schools could serve as a "release valve" for overcrowded TPSs, which may shift their school enrollment closer to an optimal scale. In this environment, TPSs are less likely to feel much competitive pressure from charter schools. By contrast, in states such as Michigan where total student population has been declining for many years, any increase in charter school enrollment translates into a corresponding reduction in TPSs enrollment and funding.

Second, school finance systems vary across states creating different incentives and constraints for schools operating within a choice policy regime. In some states, only part of the revenue follows students to charter schools when they leave TPSs so that the TPSs may even benefit financially from losing students. In Michigan, however, students take the full amount of school funding with them to charter schools, and the foundation allowance for K-12 education remained at nearly the same nominal level over the past 6 years due to sustained weakness in the state's economy. The only way for schools to obtain more educational revenue is to compete aggressively for more students. In such an environment, losing students to charter schools might reinforces a vicious cycle of revenue decline, program cuts, lower educational efficiency, and further enrollment loss in TPSs facing sustained charter competition.

Further research is needed to examine how school districts in Michigan change their resource allocation in response to choice-induced shifts in their enrollment and funding and how these adjustments relate to their ability to stabilize enrollment. In addition, research is needed to better understand the diversity of estimated competitive effects in different settings so that policymakers can design and implement policies that preserve the benefits of school choice, while minimizing the potential adverse consequences to children who are not active choosers.

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Appendix A

See Tables A.1–A.3.

Table A.1
Pooled OLS: The impact of charter competition on school efficiency, alternative measures of student achievement and charter competition.

	% satisfactory rate							
	4th grade math		4th grade reading		7th grade math		7th grade reading	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dummy charter competition								
Short-run	−17.30**	−1.67	−16.44**	−3.74*	−20.05**	.04	−16.57**	−3.43*
	(1.541)	(1.378)	(1.433)	(1.901)	(2.233)	(1.378)	(1.642)	(1.565)
Medium-run	−20.32**	−3.02	−20.73**	−7.59(	−2.96	.98	−19.42**	−6.55
	(2.029)	(2.703)	(3.557)	4.975)	(7.303)	(5.419)	(5.124)	(5.027)
Long-run	−21.78**	−4.29*	−16.3**	−7.72**	–	–	−6.93	−2.39
	(2.779)	(1.993)	(2.629)	(2.346)			(7.037)	(5.618)
Other control variables	No	Yes	No	Yes	No	Yes	No	Yes
	Standardized scale scores							
	4th grade math		4th grade reading		7th grade math		7th grade reading	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Continuous charter competition								
Short-run	−.30**	−.07*	−.21**	−.05	−.31**	−.04	−.19**	−.05*
	(0.039)	(0.035)	(0.028)	(0.028)	(0.069)	(0.03)	(0.034)	(0.021)
Medium-run	−.32**	−.04	−.23**	−.03	−.4**	−.02	−.2**	−.02
	(0.033)	(0.028)	(0.031)	(0.024)	(0.068)	(0.042)	(0.023)	(0.016)
Long-run	−.33**	−.05	−.25**	−.05	–	–	−.23**	−.04
	(0.023)	(0.031)	(0.017)	(0.031)			(0.015)	(0.025)
Other control variables	No	Yes	No	Yes	No	Yes	No	Yes

% satisfactory rate is the percentage of students who attained a "satisfactory" score in a given subject on the MEAP exam. The continuous charter competition is the log of the percentage of a district's students transferring to charter schools. See Table 5 for other notes.

Table A.2
Fixed effects, first differencing, and random trend estimations: % satisfactory rates as dependent variables.

	(1) Fixed effects (FE)	(2) First differencing (FD)	(3) Random trend model (FD + FE)
4th math			
Short-run	−1.20	−2.40*	−2.62*
	(1.422)	(1.068)	(1.014)
Medium-run	−3.02	−2.72	−3.32
	(2.323)	(1.406)	(1.743)
Long-run	−5.44*	−4.78**	−5.38*
	(2.584)	(1.814)	(2.480)
Obs.	19,649	17,484	17,484
R^2	0.32	0.18	0.18
4th reading			
Short-run	−5.63**	−4.42**	−4.02*
	(2.156)	(1.675)	(1.665)
Medium-run	−11.36*	−6.81*	−5.65
	(5.506)	(3.165)	(3.146)
Long-run	−10.3**	−13.93**	−13.38**
	(3.648)	(2.827)	(3.119)
Obs.	16,160	14,051	14,051
R^2	0.30	0.08	0.08
7th math			
Short-run	−2.56**	−0.10	0.23
	(0.748)	(1.077)	(1.160)
Medium-run	1.38	3.84	4.91
	(2.080)	(2.039)	(2.547)
Long-run			
Obs.	4965	4110	4110
R^2	0.40	0.13	0.13
7th reading			
Short-run	−5.71**	−2.85**	−2.18**
	(1.573)	(0.863)	(0.813)
Medium-run	−11.97**	−4.18*	−2.98*
	(4.121)	(1.644)	(1.418)

Table A.2 (*Continued*)

	(1) Fixed effects (FE)	(2) First differencing (FD)	(3) Random trend model (FD + FE)
Long-run	−8.85*	−8.42**	−7.37*
	(3.863)	(2.112)	(3.072)
Obs.	6407	5480	5480
R^2	0.41	0.22	0.22

The dependent variables are the % of a school's students who attained a "satisfactory" score in a given subject on the MEAP exam. See Table 6 for other notes.

Table A.3
Fixed effects, first differencing, and random trend estimations: continuous charter competition measures.

	(1) Fixed effects (FE)	(2) First differencing (FD)	(3) Random trend model (FD + FE)
4th math			
Short-run	−0.02	0.01	0.01
	(0.013)	(0.022)	(0.023)
Medium-run	−0.02	−0.01	−0.01
	(0.014)	(0.021)	(0.024)
Long-run	−0.06**	−0.04*	−0.04
	(0.015)	(0.023)	(0.026)
Obs.	19,611	17,460	17,460
R^2	0.49	0.13	0.13
4th reading			
Short-run	−0.04	−0.01	−0.003
	(0.033)	(0.025)	(0.024)
Medium-run	−0.04	−0.02	−0.01
	(0.032)	(0.027)	(0.024)
Long-run	−0.10*	−0.06*	−0.04
	(0.049)	(0.033)	(0.027)
Obs.	16,143	14,063	14,063
R^2	0.3	0.09	0.09
7th math			
Short-run	−0.01	0.002	0.004
	(0.021)	(0.019)	(0.023)
Medium-run	−0.02	0.01	0.003
	(0.028)	(0.027)	(0.034)
Long-run	–	–	–
Obs.	4980	4133	4133
R^2	0.37	0.13	0.13
7th reading			
Short-run	−0.05*	−0.02	−0.01
	(0.023)	(0.018)	(0.017)
Medium-run	−0.05*	−0.02	0.01
	(0.019)	(0.019)	(0.016)
Long-run	−0.09**	−0.03	0.02
	(0.028)	(0.023)	(0.017)
Obs.	6351	5465	5465
R^2	0.32	0.14	0.14

The continuous charter competition is the log of the percentage of a district's students transferring to charter schools. See Table 6 for other notes.

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