School Competition and Academic Quality: Evidence from Milwaukee

Nicholas S. Mader*

November 2008

Abstract

This is the first study in the school choice literature to test the effect that competitive pressure has on public school quality using data on school-level incentives. I draw data from the Milwaukee Parental Choice Program which, as the longest-running and largest private school voucher program in the United States, contains substantial cross-sectional and longitudinal variation in levels of competition intensity faced by public schools, measured by the enrollment capacity and proximity of participating private schools. First, I find that the effect of competition is positive on average although these benefits are not well distributed with schools serving the lowest income students receiving the least benefit. Second, non-linearity in competition effects implies decreasing and nearly negative returns to scale of competition for lower-income schools. I conclude that market-based incentives can be beneficial for some schools, but are not sufficient to generate public school accountability for the lowest-achieving schools.

*I am grateful for direction and support from Barbara Wolfe, Christopher Taber, Jane Cooley and Robert Meyer. I am also thankful for the generous assistance of staff at the Wisconsin Center for Education Research, particularly Ernest Morgan, Sarah Mason, and Jeffrey Watson, and at the district office of the Milwaukee Public Schools. I would also like to recognize the helpful feedback of participants in the University of Wisconsin public seminar, in particular from John Karl Scholz. All remaining errors are, of course, my own.

> "[A school choice program] would permit competition to develop. The development and improvement of all schools would thus be stimulated."
>
> Milton Friedman, *Capitalism and Freedom*, 1962

1 Introduction

The use of school-level financial or wage incentives as a means of generating improvements in public school academic quality has recently come to the forefront of educational policy reform. Of such proposals, school choice programs represent the most market-based approach of generating public school accountability, incentivizing schools to improve their academic quality in order to compete for students. The signature educational policy of the past ten years, the No Child Left Behind Act (NCLB), contains school choice provisions that are just beginning to take effect as more schools become designated as failing. Meanwhile, the expansion of school choice has been raised as a major platform issue in educational reform. But while researchers have attempted to determine the effect of school choice policies on the quality of public schools, none have yet looked to direct evidence on school-level incentives as the cause. Without understanding whether these competition incentives generate effective school accountability and how different types of schools respond to that pressure, we cannot judge if these coming school choice programs are likely sufficient to generate public school accountability, if they require complementary programs to ensure that schools respond effectively, or if other reforms can yield the same or better results.

Though there are only a few school choice programs currently implemented in the United States, the Milwaukee Parental Choice Program (MPCP) presents an opportunity to measure the effect of competition in the context of a large-scale, well-developed program. The MPCP offers low-income families vouchers for free tuition to attend private schools in the city and plays a significant role in student enrollments in Milwaukee. A recent article in the Journal Sentinel, Milwaukee's daily newspaper, reported that in the 2008-09 school year, its 19th year of existence, the MPCP exceeded 20,000 students enrollment for the first time across 127 participating private schools (of approximately 170) corresponding to almost $129 million dollars in outlays. Meanwhile the declining enrollment in the Milwaukee Public Schools (MPS) dipped below 80,000 for the first time in over a decade.[1]

Because of the scale of the MPCP, all public schools in Milwaukee are, to differing degrees, susceptible to losing students to nearby private schools and accordingly face different incentives to improve to retain their students. But although prior work of the MPCP's effect on public school quality–Hoxby (2003) and Chakrabarti (2007)–sought to test this competition theory of improvement, neither uses information on school-level incentives, instead focusing on the effect that a district-wide scaling-up of the program in 1998 had on public school test scores. To connect this policy change to school-level gains, the authors needed to make the strong assumptions that all public schools faced the same amount of competition and that all changes in school quality were caused solely by competition. By contrast, this is the first study to use measures of competition intensity that are geographically local to individual public schools. Data on these measures show that the assumptions of earlier work are incorrect, and provide a better basis for estimating the effect of school-level competition pressure on public test score gains.

I find that the effect of competition is generally positive and, though imprecise, average treatment effect estimates do suggest that previous studies have overestimated the effect. This is an expected result due to the inability of prior work to separate out factors not related to school incentives which, according to anecdotal evidence, includes a significant response of MPS to the scale-up of the MPCP. For schools that show the most positive response to competition, the effect is non-linear and concave indicating that there are significant decreasing returns to competition, even becoming negative at the margin for the highest levels of competition faced.

Perhaps the most significant departure from previous findings is in the distribution of

[1] Milwaukee Journal Sentinel, "20,000 students now use vouchers," reported November 9th, 2008 by Alan Borsuk.

effects. The two prior studies of Milwaukee found that schools enrolling the most voucher-eligible students had received the greatest benefit from competition, and conclude that these schools benefited from the highest incentive to improve. However, when I separate out influences on school quality unrelated to competition, I find that these high-eligibility schools benefit the least from competitive pressure. Because a high rate of eligibility is a marker of low income by the targeted design of the MPCP, a likely explanation of this result is that these schools lack the resources to respond effectively to competition.[2] The discrepancy in this finding across studies can also be explained by the public school district's targeting of more disadvantaged schools which made up for low benefits due just to competition. This research concludes that while market-based incentives can generate a positive response from schools, they are not sufficient to generate positive public school accountability for schools at a resource disadvantage.

The next section introduces prior research on several topics of school choice and locates this paper in that literature. Section 3 gives greater detail on the MPCP program in particular and the data used for estimation. Section 4 develops an econometric model that represents the several, and potentially confounded, causes of student achievement, and lays out the strategy for identifying competition effects. Section 5 presents estimation results, sensitivity analyses, and a brief comparison of findings to earlier research on the MPCP. Section 6 concludes.

2 Literature on School Choice

Like all educational reform efforts, school choice programs attempt to improve the quality of student education, and are often pitched with distributive concerns, tending to be proposed as a solution to ailing urban public education. Similar to other schools choice policies,

[2] Another explanation, discussed below, is that if voucher-eligible/low-income students are comparatively less responsive to school academic quality, then these schools will face less incentive to improve. Thus, even if they have capable administrators and are not resource constrained, they may choose to exert less productive effort.

which include magnet and charter schools, the first order intention of private school voucher programs is to improve school quality by making more schools accessible to students through public subsidies of tuition, presumably to offer better matches in school that are unavailable in public systems, and to open the door to high quality private schools that would otherwise be unaffordable. A second aspect of voucher program, and arguably equally as important according to choice proponents, is their potential to improve public schools by generating competition for students. Though debates over these two points have often been ideologically fueled, especially with a dearth of voucher programs having been implemented in the United States, a number of topics in these claims have been addressed by education researchers.

A first primary question taken up by the literature is whether private schools offer a higher quality education than do public schools. Witte et al (1995), Greene Peterson and Du (1996), and Rouse (1998) each compare achievement of MPS and MPCP students in the early years of the MPCP, differing in their constructions of treatment and control groups due to the substantial amount of attrition and likely non-random selection. Rouse (1998) found that voucher students had higher achievement growth in math but not reading and although it was the definitive paper in that research thread the findings were still sensitive to concerns of attrition. A recent law passed by the Wisconsin legislature prompted a new state-commissioned study of the MPCP including comparison of public versus private school value-added, titled the School Choice Demonstration Project. While the project has issued its first, baseline report, Witte et al (2008), featuring testing and surveys administered to a matched-random sample of MPS and MPCP students, evaluation of relative school quality is still forthcoming.

Several papers study the demand side of education, recognizing the difference in how educational opportunities are naturally available or guaranteed by statute in a voucher program, and how they are accessed by different households. Black (1999) and Bayer and McMillan (2005) study household sorting among communities, each identifying moderate willingness to pay for schools with higher test scores after controlling for other local public amenities. While these studies do not have close bearing on the success of school choice programs, papers such as Nechyba (2000) and Ferreyra (2005) make the link between residential sorting induced by vouchers and the resulting effect on educational quality. Each focuses on the joint decision of families to choose a residential community and a school, whether public or private. They both argue that public schools can benefit if voucher programs affect residential patterns in such a way as to increase a poor district's tax base. This occurs if higher income families choose to leave communities with high property taxes and take the voucher to attend private schools in more affordable, but still desirable, neighborhoods of a lower-income communities. But because this effect is most strongly induced by multi-district, universal vouchers, a policy measure that is likely to face political roadblocks, this approach to vouchers seems to have limited promise.

Other studies focus directly on intra-district choice in a few districts where households were able to choose among public schools. Glazerman (1998) studies household choice of elementary schools in Minneapolis using a discrete choice framework, and finds that the proximity and racial balance of schools were the primary factors in decision-making, with minimal evidence of choices being influenced by school academic quality. Similarly, Hastings Kane and Staiger (2005) study a natural experiment where households were forced to re-sort among public schools in the Charlotte-Mecklenburg school district to infer their preferences of different school characteristics. They find that find that higher SES and non-minority families have higher utility for school quality and lower disutility to choosing schools that are farther from home. As these two latter papers study choice settings nearest those generated by a voucher program, they suggest that households may not primarily use choice opportunities to access higher quality schools, or that those that would are not the primarily targeted demographic.

Another key question, the one addressed by this paper, is whether increased accessibility of private schools to students would increase competition faced by public schools, thereby forcing them to improve. Whether or not private schools have higher academic quality in general or in particulars, or households leave public schools seeking higher quality education, voucher programs can generate public school accountability if, as proponents argue, public schools respond to the threat of losing students by increasing their own academic quality. Florida's Opportunity Scholarship Program, commonly referred to as the Florida A+ Plan, grades public schools from "A" to "F" and offers vouchers to all students of schools that were persistently failing. Several studies of this program are Greene Winters (2003), West and Peterson (2006), and Figlio and Rouse (2006). These studies find positive responses of quality to schools receiving bad grades, even controlling for mean reversion. While the mechanism is somewhat unclear, whether working through the threat of lost students and the revenue they take with them or through public stigma, the visibility and transparency of the Plan's grade designations are the clear cause of academic quality gains through school-level efforts.

By contrast to the Florida A+ Plan which gives vouchers to all students of persistently failing schools, the Milwaukee Parental Choice Program offers vouchers to low-income families to attend private schools regardless of the quality of their public school. As the design of the MPCP voucher is oriented more towards accessibility of private schools than public school accountability, the identities of public schools facing competitive threat, and the level of competitive threat they face, is much harder to observe.

Hoxby (2003) studies the consequences on public school quality of several types of choice programs, including charter schools and private school voucher programs, in different US cities. That study takes up the effects of the MPCP on public school quality by focusing on a large exogenous shift in 1998 in the number of private schools participating in the program as a treatment in a regression-based difference-in-differences analysis, rather than examining direct evidence of changed incentives faced by individual schools. Hoxby finds large positive effects of the increased competition on public school quality but although she attributes the gains to increases in public school incentives to respond to competition, they are as likely due to policy interventions taken by Milwaukee public school district on behalf of the schools, an influence that she cannot separately control for.[3] Hoxby also attributes the comparatively larger gains in the quality of schools with more voucher-eligible students as being due to increased incentives to respond. Here, she is likewise unable to control for public school district intervention targeted to different types of schools, and also is unable to distinguish the internal competitive pressure to retain students due to having more voucher-eligible students from the availability of private schools nearby those schools.

Chakrabarti (2007) also studies the effect of the MPCP on public school quality focusing on scale and policy parameters of the MPCP's implementation. That study examines the effect on public school quality of the MPCP when first established compared to the effect of its 1998 scaling-up, considering that the jump in competition and the size of the vouchers varied across the two time periods. Although Chakrabarti uses more flexible estimation, adjusts for mean reversion and performs several validation checks that Hoxby does not, she finds the same large effects of the 1998 scale up and makes the same attributions to competitive incentives as does Hoxby.

This is the first study of the MPCP to directly examine the incentives faced by individual schools in terms of proximity and size of competitors, and in terms of the number of voucher-eligible students (i.e. potential leavers) enrolled by a school. A notable recent paper, Card Dooley and Payne (2008) (CDP) does take a very similar approach, using evidence from Ontario on openings and closings of private schools which, in Canada, are closely substitutable to public schools in expenditures and curriculum. There are, however, several important differences between these two studies: first, while CDP's evidence from on competition from private schools is likely stronger than that from the United States, a good deal of extrapolation is still required to predict effects in a voucher program in a low-income, primarily minority urban district. Second, their data on student achievement are less direct, with tests occurring every three grades and unable to be linked longitudinally at the student

[3]See Hess (2002) and former Milwaukee superintendent Howard Fuller's introduction to Innerst (2000) for anecdotal evidence that the Milwaukee public school district initiated significant reforms in response to the 1998 increase in scale of the MPCP.

level. Third, while their study is similiar in measuring school susceptibility to competition, using religious composition of communities whereas percent of voucher-eligible students are used here, this paper also uses the number, size, and proximity of competitors to identify scale effects of competition for each public school type. Because of their focus on the MPCP and attention to distribution of effects among schools–a key part of the investigation here–the discussion below draws comparisons with Hoxby (2003) and Chakrabarti (2007) rather than Card Dooley and Payne (2008).

The next section gives greater detail on the rules of the MPCP voucher, the means by which it generates competition among public schools, and introduces the data set that I use to investigate competitive effects.

3 Data

3.1 Milwaukee Parental Choice Program

The MPCP was authorized in 1989 and students began to attend private schools through the program in the 1990-1991 school year.[4] The program initially restricted participation to only secular private schools, which represent only about 10% of private schools in Milwaukee, until an act passed in 1995 expanded eligibility to religious schools as well. While a few religious schools began to participate in 1996 amid legal contention, it was only when the Wisconsin Supreme Court approved this measure in 1998 that the scale of the program increased dramatically in terms of both the number of participating schools and students.

The program has grown steadily after the expansion in 1998, necessitating several further rule changes to increase the enrollment cap for the popular program. Student enrollment was initially capped at 1% of MPS enrollment (about 1,000 students in 1990) and, through several policy changes, has been raised to a current cap of 22,500 student full-time equivalents

[4] For simplicity, school years will hereafter be referred to by just the fall year. Thus, 1990 would stand for the 1990-1991 school year.

(FTE). As of the fall of the 2008-2009 school year, its nineteenth year of operation, the MPCP enrolled more than 20,000 students (19,538 full time equivalents) in 127 schools, with outlays of almost $129 million. This is compared to total enrollment of just less than 80,000 students in the Milwaukee Public Schools, meaning more than one MPCP student for every four MPS students.

Aside from the 1998 rule change, the provisions of the MPCP have remained largely similar.[5] Private schools must declare their intention to participate to the state Department of Public Instruction (DPI) by February of the year prior along with expressing the amount of seating capacity they choose to make available to MPCP students in each grade. Households are eligible for the MPCP if their family income is less than 175% of the Federal Poverty Line.[6] Students already enrolled in a school through the MPCP are guaranteed continuation. For students not currently enrolled, several application periods are run from February through September where interested families apply directly to MPCP-participating schools of their choice. If the total number of applicants in a grade is equal to or below the available number of seats, all students are admitted. Notice is then sent to the DPI confirming the eligibility of the family, and full tuition payment is scheduled conditional on attendance. If the number of applicants is greater than the number of open seats, a DPI-approved random lottery is run by the school to determine the enrollment. Within this lottery process, the only preference that can be given is in the case that the student has a sibling already attending the school. If a student is not admitted to a school in the lottery process, she may transfer her application, applying to another school in another application period. Witte et al (2008), the benchmark report of the School Choice Demonstration Project, indicates that more than 70% of students are able to enroll in their first choice of school.

There are several difficulties in estimating the effect of competition as working through

[5] More recent changes in the law have increased the total enrollment cap, raised income eligibility to 225% of the Federal Poverty line for continuing students, and required accreditation for private schools. See the Wisconsin Legislative Fiscal Bureau Informational Paper 29 (2007) for further description of these changes.

[6] In 2007, the Federal Poverty Line for a four-person household was $21,203 for a corresponding MPCP eligibility threshold of $37,105.

just changing competition incentives and not other real influences or confounding factors. First, although the 1998 shift represented a large policy discontinuity, if the shift is estimated as an aggregate shock for all Milwaukee schools, as do Hoxby (2003) and Chakrabarti (2007), there is no valid control group of schools which faces increased competition incentives but not benefits due to district shifts in policy. Both prior studies construct control groups composed of non-Milwaukee schools, but this only helps separate out state or regional educational shocks and trends. This study uses data on school-level variation in levels of competition and, due to the detail in the data, can separately control for aggregate shocks at the Milwaukee level representing potentially targeted interventions.

Second, even if data on the proximity and available capacity of participating private schools are available for each public school, these competitive threats may be non-random. Private school participation is voluntary and may be systematically related to public school characteristics.[7] Even if private school decisions are exogenous with respect to school characteristics, the locations of private schools which were commonly determined many years ago may be correlated with public school characteristics. Figure 1 shows the locations of private schools in Milwaukee, which are more densely scattered in older, now lower-income, neighborhoods of Milwaukee. To control for these influences, this study uses school-level fixed effects to control for persistent school and neighborhood influences, using only longitudinal variation in competition, which I argue below is exogenous to public school quality, to identify the effect of competition.

Third, because the of nature and the scale of MPCP, the composition of the public schools is changing substantially. The characteristics of the average students may change due to either student selectivity into the program, or due to the fact that the MPCP only

[7] The direction of bias due to endogenous competition depends on the position one takes about the private school objective function. If maximizing enrollment, private schools may be more likely to enter in areas with poor public schools whose students are easy to attract. If a school's non-voucher enrollment is more responsive to peer quality than the boon of MPCP funding, then private school are more likely to enter in "better" neighborhoods that may be served by better public schools. Barrow (2001) and Downes and Greenstein (2002) provide empirical tests of private school location decisions, albeit at larger geographic scale, and outside of the context of a voucher program.

draws the students from the select student subpopulation of low-income students, who have lower achievement on average. This study uses a longitudinal data on student test scores, an important observable measure of student ability, of the universe of students in the public schools.

The next subsection describes the data used in estimation, and the following section details my strategy for identifying a competitive effect.

3.2 Data

An original data set is constructed from a number of sources, outlined below, which primarily features measures of competition intensity faced by each public school. Competition intensity is measured as the size of competing schools, weighted by their geographic proximity to the competed-with public school. The data set reflects the universe of students enrolled in Milwaukee public schools, their history of test scores which are used to measure the effect of competition, their school of enrollment which is used to connect measures of competition intensity, and other observations of student demographics.

3.2.1 Public Student and School Data

In testing for competition effects, I focus on student academic growth, measured by standardized test scores for both quantitative traction and comparability across schools. Even before NCLB mandates required widespread student testing, MPS administered standardized tests in consecutive grades starting in 2000. Both tests administered during this time frame–the Wisconsin Knowledge and Concepts Examination (WKCE) and the Terra Nova–are supplied by the test vendor wing of publishing company CTB/McGraw-Hill and achievement is measured on the same, vertically integrated scale.[8] The WKCE has been administered longer

[8] Since the 1990s, standardized tests have been scored using Item Response Theory. This is a psychometric method of estimating a student's ability as the maximum likelihood result to a joint binary response framework (i.e., the probability that a student's responses to a number of test questions, each varying by difficulty, were answered correctly or incorrectly). Test vendors will use some of the same test questions in tests for adjacent grades to ensure that these student ability estimates can be linked into an interval (though

than the Terra Nova, thus its use by studies focusing on a period around 1998. It tests mathematics, reading, language arts, science and social studies in grades 4, 8 and 10. The Terra Nova was first administered by MPS in the 2000 school year, and tests the in-between grades of 3, 5, 6, and 7, but currently covers just mathematics and reading. Though this program of testing has had a few alterations since 2000,[9] it provides a long panel for tracking student achievement growth through time. However, due to changes in scale through time, all test scores are standardized by grade and by school year to have zero mean and standard deviation of 1.

Without the ability to track individual students across MPS and MPCP enrollment, it is difficult to determine the points at which students make enrollment decisions and thus which levels of schooling face pressure to improve. Lower grades have historically seen disproportionately high MPCP enrollment and, while enrollments have evened out, most choice still appears to be first exercised there. For this reason, my analysis focuses on primary grades where test scores are available–tests in grades 3 through 5 which are merged into 3rd-4th and 4th-5th growth periods and then pooled in estimation–and defines competitors as only those MPCP participants offering capacity in primary grades.

Data on MPS students are obtained from MPS district testing and enrollment files. Though administrative data sets have generally thin records on student demographic characteristics–here, gender, race, limited English proficiency, and special education status–student receipt of free or reduced price lunch (FRL) through the National School Lunch Program is particularly meaningful. While student eligibility for the MPCP is itself unmeasured, the income eligibility threshold for FRL status of 185% of the Federal Poverty Line is very near that for

ordinal) scale.

While the interval properties of these "scale scores" are less reliable when compared across several grades, or from one end of the ability distribution to the other, they are still preferable to cruder measures such as national percentile rank or the number of test questions answer correctly. For that reason, this analysis is based off of scale scores.

[9] Main changes have been the dropping of 9th grade testing in 2005, dropping of language arts testing in 2006, the move from February testing in the 2001-02 academic year to November in 2002-03, and a change in test item content and scaling as of 2004-05.

the MPCP making it a close proxy.[10] This eligibility standard is near enough eligibility for the MPCP that several papers, including Hoxby (2003) and Chakrabarti (2007), use it as a substitute.

Table 1 shows mean and standard deviation statistics for the 2006, elementary grades, subsample. The last column represents the percentage of variation of a given student characteristic that is attributable to differences across school means. Milwaukee is a predominantly minority (87%), low-income (79% FRL) district. Cross-sectionally, the biggest difference between public schools is student racial composition although differences in FRL, English proficiency and student achievement are also significant. Longitudinally, the percentage of minority enrollment has been steadily increasing over the last several years, primarily coming from increased Hispanic enrollment and departure of whites.[11] At the same time, the number of students on free or reduced price lunch has increased by 6% across the district from 1996 to 2006. This is a particularly significant trend considering that the considerable number of students leaving MPS for the MPCP are necessarily on FRL.

It's worth noting that, by these characterizations, the MPCP is a strong test case for examining the effects of competition. Milwaukee is a district of primarily poor households that are unlikely to be able to afford private school tuition. There are 212 MPS schools (117 either K-through-5 or K-through-8) and 127 MPCP schools in Milwaukee's 97 square miles, representing a large and dense set of choices. Further, the stakes of lost funding are high given the rapidly increasing scale of the program, the historical willingness of the Wisconsin legislature to raise the cap to remove program constraints, and the virtually universal program eligibility of families.

To test the hypothesis that a school's responsiveness to competition varies by the number of eligible students it enrolls, I divide all public schools into three "eligibility class" designations in order to test heterogeneity of competition effects. Each school is assigned to

[10] See the USDA web page on Food and Nutrition Services, http://www.fns.usda.gov/cnd/Governance/notices/iegs/IEGs.htm, for income eligibility guidelines.

[11] See the MPS District Report Card (2007) for more detailed characterization of enrollment trends.

either the low number of eligible students (LE), medium eligibility of students (ME), or high number of eligible students (GE) class based on its tercile of percentage enrollment of FRL students in 2000.[12,13] Figure 2 shows the histogram of public schools distributed by their percent of students that are eligible for the MPCP and the tercile threshold cutoffs. These tercile cutoffs do a good job of separating the skewed left-hand tail of schools with comparably fewer low-income students, and splits the density of higher percentage FRL schools in half between the ME and HE classes. While the ME and HE classes seem similar in their percent of MPCP-eligible students enrolled, this distinction will provide some generality of differential effects in the estimation.

Recall that there is two-sided prior in expectations of findings for these eligibility classes. One one hand, prior work has hypothesized that the greater the number of eligible students, the greater the school's incentive to respond to a given amount of competition and thus the greater the benefit. On the other, % eligibility is directly related to the measure of economic disadvantage within a school. Thus, the greater the number of eligible students, the more resource disadvantaged a school is.

3.2.2 Competition Data

Competition intensity is measured by size of MPCP-participating private schools and their proximity to each given public school. The universe of Milwaukee private schools is identified from public use data sets managed by the DPI. These data sets include private school addresses and total student enrollments by grade by year. Total classroom capacity, related to a school's physical plant, are available from the Public Policy Forum, a non-governmental research group in Milwaukee. Data on private school histories of MPCP participation are obtained from the School Management Services office at DPI.

[12] A few schools, usually charters, first appear in the data after 2000. Their treatment class designations are based on their FRL tercile from the earliest year that they are represented.

[13] These designations are fixed rather than updated because the changes in % FRL in our sample window are as much related to immigration to the district as changes due to the program. Updating these designations would thus create arbitrary noise in the degree treated.

Measures of private-to-public school distances are calculated using street addresses in the ArcGIS mapping software with files on Milwaukee roads available from the City of Milwaukee. These measures represent minimum driving distance calculations along the city streets. In the descriptive tables below and in estimation, a competitor to a given public school is defined as a private school that participates in the MPCP and is located within a 3 mile radius of that public school, given that that is the effective outer limit that students travel to private schools found by Witte et al (2008).[14]

In terms of identifying an effect of competition, this study improves over prior literature by using more detailed data on school-level competition. The drawback in use of these data is that they only become available after 1998, the period of the greatest variation in levels competition in the MPCP. Still, there is still a steady growth in competition within the sample window and, relative to the prior work on Milwaukee, the added detail of my data set allows me to better observe changing levels of competition intensity.

Figure 3 compares the sampling windows for this paper and the two prior papers. The increase in student participation in the program, loosely representing the financial stakes for public schools in the period, is roughly the same across all studies, but the earlier sample window does show more variation in the number of participating schools. There is still a sizeable amount of variation in competition available in this study from focus on the later sample window for two reasons. First, the slow increasing trend of school participation in Figure 3 is only a measure of net increase, and does not show the good deal of both entry and exit, shown in Table 2, both of which generate variation in levels of competition faced by public schools. Second, the availability of measures of proximity and school size also contain information about competition intensity beyond just the number of entering and exiting competitors. As a final note on identification, the later sample window is desirable

[14] Milwaukee is 97 square miles in area, and runs much longer north-south than east-west as it runs along Lake Michigan. Its western border is also irregularly shaped. In a city with a perfect grid, a 3-mile radius would cover 18 square miles, approximately one-fifth of the city's area. Due to Milwaukee's shape, especially along its western edge, this radius includes less ground, making the point that even this large radius results in substantial cross-sectional variation in competition faced by public schools.

in its own right as it is inside the medium run of the program, a period where competition is likely less confounded by other district interventions.[15]

Table 3 shows average levels of competition intensity at the school level, showing characteristics of competitors within three miles faced by the average school in the average year. By breaking these averages down by the different eligibility classes, it is clear that there is a strong, positive association between school eligibility/disadvantage and the level of competition faced. As mentioned above, this association may either be a strategic endogeneity where private schools select into participation in order to compete for certain students, or may be due to correlation of private school location density with public school characteristics.

Because private school participation decisions may be endogenous to public school quality, I use fixed effects in estimation to control for the levels of persistent public school quality. This means that the competition effect is identified only by the variation that each given school faces across time. Though the total amount of observed variation in competition threats is reduced by discarding cross-sectional variation in estimation, Table 4 demonstrates that there is a substantial amount of within-school longitudinal variation, enough to be economically significant as a competitive threat. These standard deviations represent the distribution of competition intensity that a given school faces across the six year window. Again, note that these measures understate the total amount of variation in competitive threat since, in estimation, these measures of competition intensity are also weighted by proximity to the competed-with schools.

Similar to Table 3, when the numbers in Table 4 are broken down by school eligibility class, there is a clear positive correlation between changes in competition intensity across time and the number of MPCP-eligible students in a given school. This association, however, does not confound estimation of competition effects but does indicate differential statistical power in the estimation of separate effects by eligibility class. The next section discusses specification and identification of those effects.

[15] Long run phenomena are just starting to be observed in Milwaukee such as declining enrollment in the MPS, closure of public schools, and founding of private schools as a direct response to the MPCP.

4 Econometric Model

School quality is measured as academic growth net of student-level inputs. The student achievement function is modeled as

$$y_{it} = \left[\lambda y_{it-1} + x'_{it-1}\beta + \kappa_i\right] + \left[\phi_{j(i)} + \nu_{j(i)t-1} + \rho_{l(j)} + c'_{j(i)t-1}\gamma_{l(j)}\right] + \left[\pi_{t-1} + \theta_{t-1l(j)}\right] + \varepsilon_{ij(i)t} \tag{1}$$

where i indexes students, $j(i)$ the school attended by student i, $l(j)$ the eligibility class of school j, and t time. Due to the number of terms, student, school, and other influences are separated into bracketed groups to improve readability. Student factors in achievement include lagged achievement y_{it-1}, demographics x_{it}, and an unobserved student-level persistent effect κ_i. School-level factors are decomposed into each school's persistent quality $\phi_{j(i)}$, mean-zero time-varying quality $\nu_{j(i)t}$, the average quality of schools in a given eligibility class $\rho_{l(j)}$, and the influence of competitive pressure represented by the vector $c_{j(i)t-1}$.[16] The parameter vector γ, representing the quality response of schools to competition, may vary with the school's eligibility class and is subscripted with l. Other potential influences are represented by time-specific shocks π_t and time-specific shocks for each eligibility class of schools $\theta_{tl(j)}$. Residual error is represented by $\varepsilon_{ij(i)t}$ which, given other controls, is assumed to be independent and identically distributed.

Regarding the timing of effects, each student post-test is matched to test scores and demographic variables of the prior academic year. Because tests are generally administered in November in my sample window, the winter/spring portion of the prior year is the largest growth period from test-to-test. For this reason, I use prior year values for time-dependent regressors such as limited English proficiency, FRL status and school of enrollment, and thus the $t-1$ subscript and interpretation for many effects.

[16] Competition variables are constructed so that increasing values represent increasing competition. For example, the distance of a competitor to a public school is converted to proximity by a sign change.

4.1 Identification of School-Level Factors and Competition Effects

One of the key challenges in identifying the effect of competition is endogeneity of private school participation decisions to public school academic quality. From Table 4 above, given that schools with more eligible students have lower test scores, it is clear that $Corr\left[\left(\sum_t c_{j(i)t-1}\right), \phi_{j(i)}\right] \neq \mathbf{0}$. This is easily handled in estimation by use of school-level fixed effects to control for $\left\{\phi_{j(i)}\right\}_{j=1}^{J}$. But though use of fixed effects soaks up the average level of competition a school faces, there may still be confounding with public school quality if $\mathbb{E}\left[\left(c_{j(i)t-1} - \overline{c}_{j(i)t-1}\right) \nu_{j(i)t-1}\right] \neq \mathbf{0}$, the case where private school participation decisions are related to fluctuations in public school quality. This type of confounding is unlikely for two reasons. First, year-to-year fluctuations in public school quality, as separate from student average test scores, are difficult for even researchers to detect, making $\nu_{j(i)t-1}$ hard for private schools to act on. Second, even if public school quality was a major factor in participation decisions, each private school has only one participation decision to make to compete with students from several public schools at once.[17] So long as quality fluctuations are not correlated across public schools in a given area then even purely strategic behavior would be unlikely to create any meaningful bias. The $\nu_{j(i)t-1}$ are not estimated directly as they would soak up all variation in competition, but are represented in estimation by the use of clustered standard errors at the school-by-year level.

I use private school physical seating capacity as the measure of competition intensity to capture the fact that private school size, and thus potential to offer many seats through the MPCP, varies substantially. Because this measure is a property of a school's building capacity rather than an administrative decision of seats available, it is much less likely to be correlated with public school performance. If, for example, a public school's quality dipped in a given year for exogenous reasons and students left for the MPCP, the choice of private school MPCP enrollment or total enrollment as a measure of competitor size might increase,

[17] On average, there are more than 3 public schools within a one mile radius of any private school, and more than 12 within a two mile radius.

generating a spurious, negative competition effect. While this measure of private school physical capacity does vary slightly over time, I use time-averaged measures of each school's physical capacity in order to capture its size without introducing noise.

Note that because each school is uniquely mapped to an eligibility class, my use of school-level fixed effects will in practice reflect $\phi_{j(i)} + \rho_{l(j)}$, identifying only total school quality, and not school quality relative to eligibility class means. In practice, these levels are not separately identified from the intercept term, and in estimation I normalize the regression intercept to zero.

The data used in this study permit identification of non-linear returns to the scale of competition as continuous measures of competition intensity can be used in polynomial constructions of $c_{j(i)t-1}$. By contrast, both Hoxby (2003) and Chakrabarti (2007) use a regression-based difference-in-differences framework similar to that in (1) but, because neither has a direct measure of competition faced by each school, $c_{j(i)t-1}$, they use the regression term τd_t to capture changes in competition after 1998. The indicator variable d_t is equal to 1 if $t \geq \bar{t}$, where $\bar{t}$ represents the first year after the scale-up of the MPCP, and 0 otherwise, meaning that τ is interpreted as the total effect from the increase of competition in that period. An estimate of $\widehat{\gamma}$ could be recovered by calculating, for example, $\widehat{\gamma} = \widehat{\tau} / \left[\frac{1}{NJ} \sum_j n_j \left(c_{jT} - c_{jT-1} \right) \right]$ where J is the total number of schools and n_j is the number of students at a given school, portioning out the total effect by the change in levels of competition. But because they have only a scalar estimate of school quality response, this inversion only works for a unidimensional measure of c such as the number of competitors. Without more detailed information on levels of competition faced by each given school, they are unable to estimate a non-linear effect, or non-constant returns to scale in competitive benefit.

4.2 Identification of Non-Student, Non-School Effects

Another key concern for identification is the potential for non-competition related influences to be confounded with competition. In Milwaukee, policy intervention by the public school district likely induced $\pi_t > 0$ for all years $t \geq \bar{t}$. If that intervention was targeted to the schools with relatively greater economic disadvantage, then $\theta_{tl(j)}$ would also increase with the number of eligible students in a given school for $t \geq \bar{t}$. Note that these controls will soak up all non-competition influences at their respective levels. This includes not only quality changes due to Milwaukee interventions but are also controls for school responses to other time-varying and targeted effects on public school quality such as NCLB. Because I de-mean student achievement by year and grade, I effectively difference out π_t just as use of fixed effects by year would. I control for the $\theta_{tl(j)}$ by use of fixed effects at the year-by-eligibility class level. This is possible because the data has variation of competition measures faced by schools within year and within year-by-class combinations.

The lack of this data in prior work on the MPCP makes identification impossible without assumptions that prove to be untenable. Hoxby (2003) and Chakrabarti (2007) lack school-level data on competition intensity, and estimate the effect of competition that is due to the shock of increased competition in periods after the MPCP scale-up. But because they cannot separate this from the shock of district response π_t that occurs at the same time, they obtain identification of just a competition effect by implicitly assuming that $\pi_t = k \; \forall t$ for constant k. I.e., they assume that there are no (changing) influences on public school quality other than the MPCP. If we believe that $\mathbb{E}\left[\pi_t | \, t < \bar{t}\right] = 0$, representing no district intervention on average before the scale-up, and $\mathbb{E}\left[\pi_t | \, t \geq \bar{t}\right] > 0$, then then $\widehat{\tau}$ will be upwardly biased by $\mathbb{E}\left[\pi_t | \, t \geq \bar{t}\right]$.

To obtain estimates of heterogeneous response of schools to competition, the prior studies use a series of regressors $d_t d_{l(j)}$ where $d_{l(j)}$ is a dummy variable indicating (their analog of) eligibility class. In this way they estimate a series of total effect estimates $\tau_{l(j)}$. For these estimates to be unbiased, they require the assumption that no other influences on school quality are correlated with its number of eligible students, or $\theta_{tl(j)} = k_l \; \forall t$ for constant k_l. Instead, if the public school district targeted its intervention, each estimate $\widehat{\tau}_l$ will be biased upward by the average θ_{lt} in the period $t \geq \bar{t}$. If the intervention is targeted in proportion to l (the eligibility class of a school), then it will be incorrectly concluded that schools with greater l are more responsive to competition.

4.3 Identification of Student-Level Factors

The several direct measures of student-level factors represented in Table 1 are all included in the regression analysis. The use of test scores as a regressor requires particular attention because it is a noisy measure of student ability. This is a standard econometric problem in which the presence of measurement error will bias the pretest coefficient λ towards zero, and will thus bias the regression coefficients of other variables in direct proportion to their correlation with the pretest variable. The solution to this problem, however, is non-standard because reliable estimates of the variance of noise in test scores is available. In their estimation of student scale scores, test vendors commonly calculate and report the curve of heteroskedastic error as a function of student ability.[18] Thus, an average variance of noise can be estimates given the scale scores of a student population.

I correct for measurement error in the pretest variables using the synthetic instrumental variables technique described in Meyer (2001). The intuition for this method is that we have enough information to construct a theoretically perfect instrument for the pretest. The covariance structure between the posttest, pretest and synthetic pretest is

[18] This is simply the inverse of the information matrix yielded from their maximum likelihood estimation of student scale scores. The intuition of this heteroskedasticity is that the ability of a test to discriminate among student abilities depends on how well its content is matched with the ability of the student. Scale scores from a 3rd grade reading test will have much higher reliability when testing a student that is at a 3rd grade reading level rather than one at a 2nd grade reading level.

$$
\begin{array}{c|ccc}
 & y_t & y_{t-1} & y_{t-1}^{synth} \\
\hline
y_t & \sigma^2_{post} & & \\
y_{t-1} & \sigma_{post,pre} & \sigma^2_{pre} & \\
y_{t-1}^{synth} & \sigma_{post,pre} & \sigma^2_{pre}-\sigma^2_{err} & \sigma^2_{pre}
\end{array}
\qquad (2)
$$

That is, the synthetic pretest has the same variance and covariance with all other regressors (including the posttest) as does the real pretest, but its covariance with the real pretest is equal to the pretest's variance minus the variance of noise σ^2_{err}. As in standard IV, the observed pretest is estimated using the synthetic pretest and all other exogenous factors in the model, and this predicted value is used in estimation of the outcome variable. But because the synthetic instrument is not directly observed, but is instead defined by a population-based moment, the synthetic instrumental variables technique is implemented by forming the cross-product matrix of regressors, adding a row and column representing the synthetic instrument similar to (2), and proceeding with estimation. I then impose the unbiased estimate of $\widehat{\lambda}$ on the data by reconstructing the dependent variable as $\left(y_{it} - \widehat{\lambda} y_{it-1}\right)$, and estimate (1) with the fixed effect and clustered standard errors as described above.

The estimation here is unlikely to be affected by compositional shifts in students enrolled in MPS, even though a substantial number of students leave to the MPCP. The administrative data that I use reflect the universe of student in MPS and due to the longitudinal data structure and the availability of prior test scores at the individual level, measures of growth are not affected by changes in a school's composition. Though I do not control directly for κ_i, because I have data on prior test scores which capture a large amount of variance in student future achievement, the residual, unobserved portion of student achievement $\mathbb{E}\left[\mu_i | x_{it}, y_{it-1}\right]$ would generate small selection bias.

Although I do not have access to data on students in the MPCP to judge the extent of selection, the Witte et al (2008) report finds no strong evidence of cream-skimming of students by ability into the MPCP. They interview and administer tests to random samples of students in the MPCP and of MPCP-eligible students in MPS. They find that the two student subsamples have very similar test scores, with MPCP students actually scoring slightly lower, contrary to the typical concern of cream-skimming. Even looking at usually unobservable student and family characteristics in surveys, there is no strong evidence to indicate that one population is more likely to outperform the other. MPCP parents are somewhat more involved in parent-teacher organizations while MPS parents are somewhat more involved in reading to their children and checking homework.

I do not estimate student-level fixed effects because, as described above, the availability of student-level test scores likely correlates and thus partially controls for unobserved persistent ability, because students do not seem selected into or out of the sample on this basis, and in order to preserve a large number of degrees of freedom in estimation.

5 Results

Table 5 shows estimated coefficients from a range of a progression of regression sensitivities for mathematics and reading tests. All specifications include controls for student pretest, demographic variables, fixed effects by school and by school eligibility class by year, and clustered standard errors by school by year, as described above. In all specifications, the chief measure of competitive threat is the average classroom capacity of competitors in seats by grade. The competitive threat faced by each public school is that measure summed across all competitors within a three mile radius.

To begin building intuition for the findings of the preferred model, Model 1 uses just a single treatment variable of summed competitor capacity along with the above controls. The intuition follows the simple association claimed by voucher proponents, than an increase in competition intensity should raise public school quality. The estimated effect for both math and reading, shown in panels 5a and 5b, are very imprecise. This is a likely expected outcome since, while most students travel no more than three miles, the findings on household preferences of Glazerman (1998) and Hastings Kane and Staiger (2006) suggest that a private school's ability to compete for a school's students is strongly related to its proximity.

Model 2 uses the linear measure of competition intensity and adds a measure of competition intensity interacted with the proximity of each competitor. Still, neither regressor is statistically significant and, for both math and reading, the likelihood ratio tests indicate that we fail to reject the joint null of zero effect of competition. The addition of the interacted term adds little enough descriptive power that the p-values in the joint test increase for both subjects. Again, this is still relatively naive estimation in its restriction of linear effects of competition intensity for what is a substantial range of levels of competition faced by public schools.

In prior expectations, we would likely hypothesize non-linear, particularly concave, response of public school quality to competition. Many mechanisms have been suggested as drivers of public school improvements due to competitive incentives, but these mechanisms may not all be in play at the same time and are not likely to yield constant returns. First, the dominant hypothesis of the benefit to competition is increased administrative or teacher effort in innovating curriculum, engaging students, and reallocating teacher or financial resources toward more "productive" ends. If resource constraints become binding or if there are less than constant returns to this behavior then the loss of financial resources, which is linear in the number of students lost, can conceivably generate net losses for schools.

Second, there may be limitations of competition to generate the right type of economic incentives. McMillan (2004) uses a theoretical analysis parallel to industrial organization theory, demonstrating that schools serving students that are inelastic consumers with respect to quality will exert less costly effort to improve than would those serving high-elasticity students. Relatedly, if a school's high-elasticity students are competed away, its optimal response may be to decrease effort. Indeed, the findings of Hastings Kane and Staiger (2006) lend support to McMillan (2004)'s assumptions of family choice behavior, showing that lower-income families have a high rate of substitution of quality for proximity of schools.

Third, the educational production function may be non-linear in inputs influenced by competition. Competition may actually benefit urban schools by competing away students and reducing over-crowding in classrooms. Changing student composition of schools may also be a driver through peer effects, although the effect is somewhat ambiguous. While Rouse (1998) indicates that higher performing students selected into the MPCP in early years, Witte et al (2008) fails to find much difference in MPCP and MPS populations in later years. Given that only low-income students are eligible for the MPCP and those students score lower, on average, than other students in each given school, a lack of selectivity in student departures from the low-income subpopulation would draw away the lowest-achieving peers. But even if these several influences are salient, their effects are also likely to eventually have decreasing benefits.

To begin to capture non-linearity in the effect of competition intensity, Model 3 adds a quadratic term in competition intensity. The coefficient on this estimated quadratic term is negative, and significantly so for mathematics. But while inclusion of the term decreases the p-value in the joint null test relative to Model 2, we still fail to reject the null of zero effect. Finally, Model 4 adds generality to non-linear estimation of competitive effects by including the full polynomial of linear, quadratic and interacted regression terms combining competition intensity and proximity.

The final important innovation in the model's generality is to allow the quality of schools of different eligibility classes to respond heterogeneously to competitive threat. Model 5 shows three columns of regression coefficients, each corresponding to a given eligibility class. This estimation rejects the joint null of zero at the 1% level for mathematics and while the p-value decreases substantially in estimation for reading, we still fail to reject the null. This improvement in descriptive power is consistent with the hypothesis that schools with greater or fewer numbers of eligible students–and accordingly those serving a more or less disadvantaged group of students–face either different incentives or have different resources to respond to competitive threats.

Although the use of the polynomial in Model 5 permits flexible estimation of non-linearities in competition effects, the number of coefficients on regression variables that are all highly correlated makes it difficult to determine marginal effects and magnitudes of predicted effects in the support of the data. Table 6 shows calculations of the Average Treatment Effect (ATE) for the three different eligiblity classes. These calculations represent the effect of competition actually faced by schools relative to zero competition to get a sense of the magnitude of effect that the program has had. Even though the sample window for the study is after 1998, these are valid estimates of program effect due to competition–and not relative to school quality at the beginning of the sample–with the only limitation that these numbers require reliable extrapolation to zero competition.

The ATE is estimated as

$$\bar{\bar{\tau}}_l = \frac{1}{T} \sum_t \frac{1}{N_t} \sum_j n_{jt} c'_{jt} \widehat{\gamma}_l \tag{3}$$

where T represents the number of years in the sample window, N_t the total number of students in the estimation data at time t, and n_{jt} the number of students in school j at time t. Note that the n-weighting gives these average effect estimates the interpretation of the program's influence on student- rather than school-level outcomes.

Table 6 shows a similar pattern of ATE for both subjects, where schools with the middle amount of MPCP-eligible students receive the highest competition benefit. This result is consistent with the theory that levels of student eligibility has a two-sided effect of increasing competition incentives, dominant at lower levels, and signaling limited resources to respond to competition when at higher levels. Although these estimates are imprecise, they are uniformly below the estimates of Hoxby (2003) and Chakrabarti (2007), particularly for schools with the most eligible students which they conclude are the most responsive in quality to competition.

Because the effect of competition is not a binary treatment, part of the noise in Table

6 is in averaging across schools facing higher and lower levels of competition. To view this variance and gain intuition on the curvature of each effect, I draw out effects curves as the inner product of a vector of regression coefficients with a vector of competition intensity measures of the typical competitor faced. The effect curves are calculated as

$$\widehat{\tau}\left(m,p,n,l\right)=\left(\begin{array}{ccccc} nm & \left(nm\right)^{2} & nmp & np & \left(np\right)^{2}\end{array}\right)\widehat{\gamma}_{l} \tag{4}$$

where $\widehat{\tau}$ is the estimated competition effect, m is the measure of competition intensity of the average competitor (average physical classroom capacity), p is the proximity of the average competitor, n is the number of average competitors faced, and $\widehat{\gamma}_{l}$ is the vector of regression estimates for eligibility class l taken from Table 5.

Table 7 shows the characteristics of the average competitor faced, calculated from the data across all schools. When calculated separately across schools of different eligibility classes, the characteristics of the average competitor are almost exactly the same. So while schools of different eligibility classes face different levels of competition (shown in Table 3), this is explained by a higher average number of competitors rather than due to differences in the characteristics of competitors faced.

Figures 3a and 3b show the effects curves for each eligibility class of schools for different levels of competition intensity, traced out in the number of the average competitor faced. In order to view the support of the data, each curve shows dots indicating deciles in the number of competitors faced by its respective eligibility class of school. In each set of effects curves, schools in the high-eligibility class either receive the least benefit or are harmed by the program. Only the medium-eligibility class curves show substantial non-linearity, being concave and negative at the margin at higher levels of competition. Looking at the decile dots, there is a substantial density of ME schools facing levels of competition on the downward slope in the data. This suggests that these negative marginals, while not substantial, truly represent decreasing returns to scale and are not due to restrictions on functional form of the polynomial.

Given that Figure 3 represents data from all years in the sample window and the scale of the MPCP has been increasing, schools are on average on the higher competition end of the curves in recent years. This means that schools in both the middle-eligiblity and high-eligiblity classes face either low or negative marginal effects from further increases in competition faced. This result is presented in Figure 4 where the average marginal effect for each class of school is plotted with 2σ error bars. These are calculated separately by year as

$$\widehat{\mu}\left(m,p,n,l,t\right) = \sum_{j} n_{jt}\left(\widetilde{c}_{jt} - c_{jt}\right)' \widehat{\gamma}_{l} \tag{5}$$

$$\widetilde{c}_{jt} = \begin{pmatrix} [c_{jt}]_1 + m & \left([c_{jt}]_1 + m\right)^2 & \left([c_{jt}]_1 + m\right)\left([c_{jt}]_4 + p\right) & \left([c_{jt}]_4 + p\right) & \left([c_{jt}]_4 + p\right)^2 \end{pmatrix}'$$

where $\widetilde{c}_{jt}$ is a vector of polynomial terms starting with observed competition ($[c_{jt}]_1$ and $[c_{jt}]_4$ representing values of competitor capacity and proximity in levels) and adding the characteristics of an additional, average competitor to construct interacted and quadratic terms. The non-linearity of the medium-eligibility class in Figure 3 is clear in Figure 4 where, as time goes on and these schools face more competition, moving them farther along the effect curve, the average marginal effect steadily decreases.

While in general we do see positive effects of increased competitive threat to public schools, though imprecise, these effects are not well distributed to Milwaukee's lowest-achieving schools. Though the financial stakes of the program for public schools have remained fairly constant, meaning increasing financial losses in total as students continue to leave MPS, the marginal yield per dollar in terms of public school performance is decreasing. I conclude that while competition may be an effective means of inducing of public school quality improvements for some schools, it is not sufficient as an accountability measure for improving the lowest quality schools. Those schools need either district support or increased resources in order to respond effectively to competition, or perhaps other public accountability mechanisms should be explored for better academic yield per dollar.

6 Conclusion

This is the first study of private school voucher programs to examine school-level incentives to respond to competition threats by improving academic quality. I construct an original data set of public schools in Milwaukee in the context of the Milwaukee Parental Choice Program, the longest-running and largest voucher program in the United States. Previous studies of public school improvements due to the establishment of voucher programs estimate total effects which include school improvements related to public school district policy reforms as well as other uncertain influences in addition to competition effects. By using better data to isolate a competitive effect, I am able to judge the sufficiency of competition effects to generate positive public school accountability particularly for schools with different levels of resources.

I find that while competition effects are generally positive, schools with the most low-income students receive the least benefit. I also find non-linearity in the effects such that, at the current high levels of competition in the Choice Program, the marginal effects of increasing competitive threat are either small or negative for schools serving the most disadvantaged students. This is consistent with the concern that, despite evidence of gains in school academic quality to competition, resource constraints limit or erode gains due to competition. I conclude that competitive threats are not sufficient to generate effective public school accountability for the lowest income schools, that support or increased resources may help them respond effectively to competition, or that other public accountability systems should be examined as either complements or substitutes.

References

[1] Barrow, Lisa (2001): "Private School Location and Neighborhood Characteristics" Federal Reserve Bank of Chicago.

[2] Bayer, Patrick and Robert McMillan (2005): "Choice and Competition in Local Education Markets," NBER Working Paper 11802.

[3] Black, Sandra (1999): "Do Better Schools Matter? Parental Valuation of Elementary Education," *Quarterly Journal of Economics*, Vol. 113, No. 2, 577-599.

[4] Borsuk, Alan (2008): "20,000 Students Now Use Vouchers," Milwaukee Journal Sentinel, November 9th, 2008 (http://www.jsonline.com/news/education/34184444.html).

[5] Card, David, Martin Dooley, and Abigail Payne (2008): "School Competition and Efficiency with Publicly Funded Catholic Schools," National Bureau of Economic Research Working Paper No. 14176. Cambridge, MA: NBER.

[6] Chakrabarti, Rajashri (2007): "Can Increasing Private School Participation and Monetary Loss in a Voucher Program Affect Public School Performance? Evidence from Milwaukee" *Journal of Public Economics, Forthcoming.*

[7] Downes, Thomas and Shane Greenstein (1996): "Understanding the Supply Decisions of Nonprofits: Modelling the Location of Private Schools" *The RAND Journal of Economics* Vol. 27, No. 2 pp. 365-390.

[8] Downes, Thomas and Shane Greenstein (2002) - "Entry into the Schooling Market: How is the Behaviour of Private Suppliers Influenced by Public Sector Decisions?" *Bulletin of Economic Research* Vol. 54, No. 4.

[9] Ferreyra, Maria (2007): "Estimating the Effects of Private School Vouchers in Multidistrict Economies," *American Economic Review*, Vol. 97, No. 3, pp. 789-817.

[10] Figlio, David and Cecelia Rouse (2006): "Do Accountability and Voucher Threats Improve Low-Performing Schools" *Journal of Public Economics* 90, pp. 239-255.

[11] Friedman, Milton (1962): "Capitalism and Freedom," University of Chicago Press, Chicago, IL.

[12] Glazerman, Steven (1998): "School Quality and Social Stratification: The Determinants and Consequences of Parental School Choice," Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA April 13-17 1998.

[13] Greene, Jay, Paul Peterson and Jiangtao Du (1997): "The Effectiveness of School Choice: The Milwaukee Experiment," Harvard University Education Policy and Governance Occasional Paper 97-1, March 1997.

[14] Greene, Jay and Marcus Winters (2003): "When Schools Compete: The Effects of Vouchers on Florida Public School Achievement," Manhattan Institute for Policy Research, Working Paper.

[15] Hastings, Justine, Thomas Kane, and Douglas Staiger (2005): "Parental Preferences and School Competition: Evidence from a Public School Choice Program". *Yale Economic Applications and Policy Discussion Paper No. 10.*

[16] Hess, Frederick (2002): "Revolution at the Margins: the Impact of Competition on Urban School Systems," The Brookings Institution Press, Washington, DC.

[17] Hoxby, Caroline (1994): "Do Private Schools Provide Competition for Public Schools?" National Bureau of Economic Research Working Paper No. 4978. Cambridge, MA: NBER.

[18] Hoxby, Caroline (2003): "School Choice and School Competition: Evidence from the United States," *Swedish Economic Policy Review.*

[19] Innerst (2000): "Competing to Win, How Florida's A+ Plan Has Triggered Public School Reform," The Center for Education Reform.

[20] Meyer, Robert (2001) - "An Evaluation of the Effectiveness of the Urban Systemic Initiative and Other Academic Reforms in Texas: Statistical Models for Analyzing

Large-scale Datasets." Report prepared for the National Science Foundation. Madison: Wisconsin Center for Education Research.

[21] McMillan, Robert (2004): "Competition, Incentives, and Public School Productivity", Journal of Public Economics 88, pp. 1871-1892.

[22] Milwaukee Public Schools (2007): "MPS 2006-2007 District Report Card," (http://www2.milwaukee.k12.wi.us/acctrep/0607/2007_district.pdf)

[23] Neal, Derek (1997): "The Effects of Catholic Secondary Schooling on Educational Achievement," Journal of Labor Economics, XV, 98-123.

[24] Nechyba, Thomas (2000): "Mobility, Targeting, and Private School Vouchers," *American Economic Review*, Vol. 90, No. 1, pp. 130-146.

[25] Rouse, Cecelia (1998): "Private School Vouchers and Student Achievement: An Evaluation of the Milwaukee Parental Choice Program," *Quarterly Journal of Economics,* Vol. 113, No. 2, 553-602.

[26] USDA Income Eligibility Guidelines for the National School Lunch Program (http://www.fns.usda.gov/cnd/Governance/notices/iegs/IEGs.htm)

[27] West, Martin and Paul Peterson (2006): "The Efficacy of Choice Threats Within School Accountability Systems: Results From Legislatively Induced Experiments," *The Economic Journal*, 116, pp. C46-C62.

[28] Wisconsin Legislative Audit Bureau Report (2008): "Milwaukee Parental Choice Program," Informational Paper 29.

[29] Witte, John, Christopher Thorn, and Kim Prichard (1995): "Private and Public Education in Wisconsin: Implications for the Choice Debate," University of Wisconsin, mimeo.

[30] Witte, John, Patrick Wolf, Joshua Cowen, David Fleming, and Juanita Lucas-McLean (2008) "MPCP Longitudinal Education Growth Study: Baseline Report," School Choice Demonstration Project, Milwaukee Evaluation Report #5.

Figure 1. Total and MPCP Enrollment in Milwaukee Private Schools, 2006-07

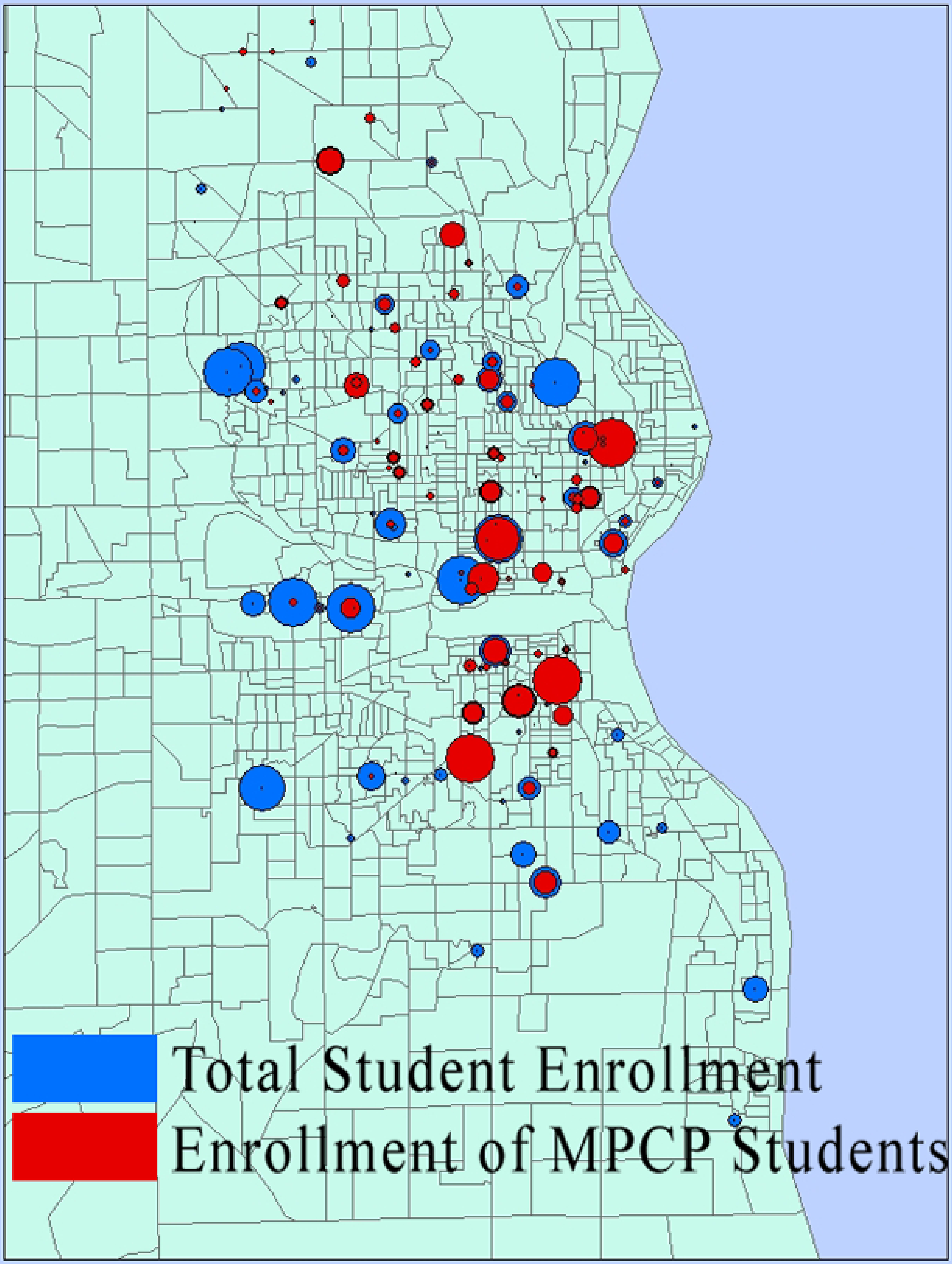


Table 1: Student and School Descriptive Statistics

Student Subsample: 3rd-5th Grade, 2006, N = 9,446

Variable	Scale	Mean	Std. Dev.	Between/ Total Var
Posttest	N(0,1)	0.01	0.98	10%
Pretest	N(0,1)	0.02	0.95	12%
Simple Gain	ΔN(0,1)	-0.01	0.77	4%
Asian	0/1	0.03	0.17	7%
Black	0/1	0.59	0.49	56%
Hispanic	0/1	0.24	0.43	58%
Native Am.	0/1	0.01	0.09	1%
Female	0/1	0.49	0.50	1%
Limited English Proficient	0/1	0.09	0.29	22%
Free/Reduced Price Lunch	0/1	0.79	0.41	14%
Special Ed	0/1	0.16	0.36	2%

Figure 2. Histogram of Schools by % of Students Eligible

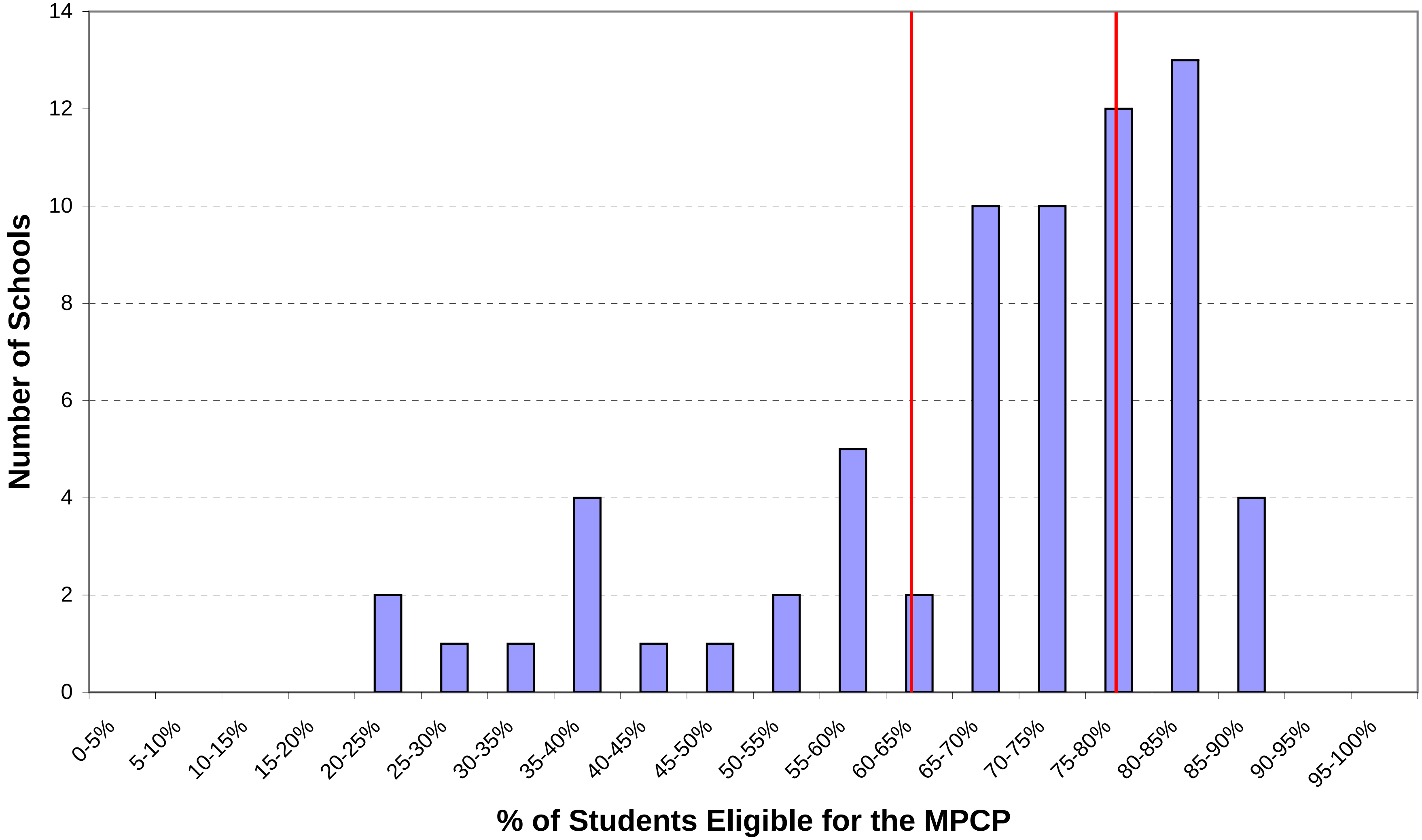
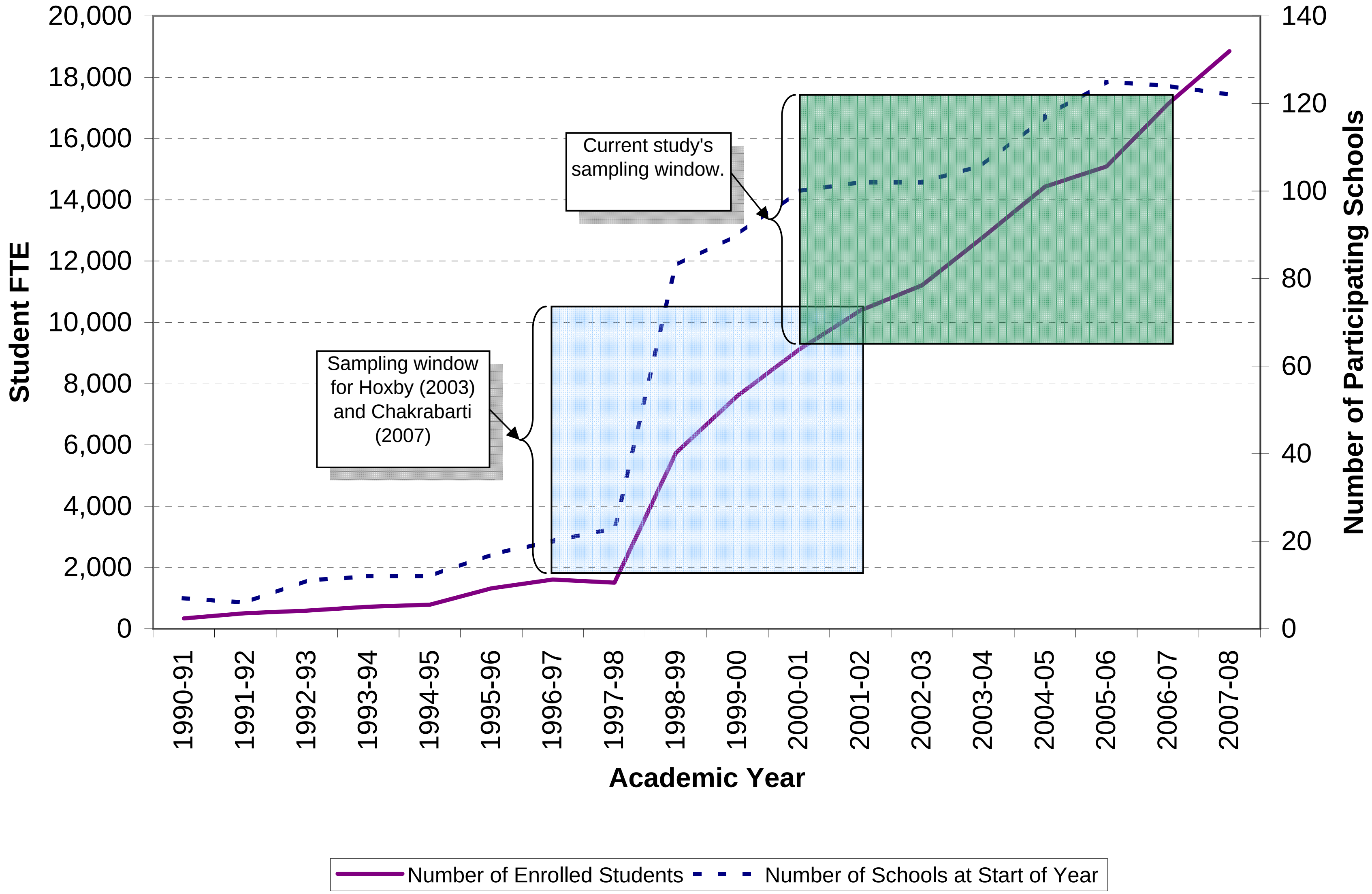


Table 2: History of MPCP Participation

Academic Year	Number of Participants	Entries	Exits
1990-91	7		
1991-92	6	0	1
1992-93	11	5	0
1993-94	12	1	0
1994-95	12	0	0
1995-96	17	5	0
1996-97	20	7	4
1997-98	23	5	2
1998-99	83	65	5
1999-00	90	15	8
2000-01	100	13	3
2001-02	102	8	6
2002-03	102	9	9
2003-04	106	5	1
2004-05	117	18	7
2005-06	124	17	10
2006-07	120	9	13
2007-08	122	13	11

Source: Author's Calculations using DPI documents on MPCP historical headcounts.

Figure 3. MPCP History of Participating Students and Schools



Source: Data is from Wisconsin Department of Public Instruction's MPCP "Membership History and Payment Archive" file.

Table 3: Levels of Competition by Eligibility Class

	Average Levels				Relative to All Sch's		
	All Schools	Low Eligibility	Medium Eligibility	High Eligibility	Low Eligibility	Medium Eligibility	High Eligibility
# Competitors :	26	21	23	33	0.81	0.88	1.27
Competitor Student Enrollment per Grade, Summed :	448	384	379	586	0.86	0.85	1.31
Competitors' Physical Capacity in Seats per Grade, Summed:	500	418	433	650	0.84	0.87	1.30

Table 4: Longitudinal Variation in Competition by Eligibility Class

	Average Within σ			
	All Schools	Low Eligibility	Medium Eligibility	High Eligibility
# Competitors :	3.2	2.3	3.3	3.9
Total Student Enrollment :	47.2	40.8	46.5	52.9
School Physical Capacity in Seats:	113.2	81.4	102.5	144.1

Table 5a: Coefficients of Test Scores on Competition
Student Subsample: 3rd - 5th Grade, Subject: Math

Variable	Scale	(1) Linear Competition Intensity	(2) Prox-Weighted Intensity	(3) Quadratic Competition Intensity	(4) Prox-Weighted Polynomial	(5) Low Eligibility	(5) Medium Eligibility	(5) High Eligibility
Competitor Capacity	Σ (Int/1000)	-0.006	-0.069	0.461	0.470	4.457***	-0.019	-2.067
		(0.180)	(0.338)	(0.438)	(0.697)	(1.305)	(1.128)	(1.397)
Competitor Capacity^2	(Σ (Int/1000))^2	-	-	-0.951*	-2.629	-3.683	0.725	0.229
				(0.503)	(1.762)	(4.274)	(2.835)	(2.734)
Capacity * Proximity	Σ ((Int/1000)*Mi./100)	-	-0.061	-0.814*	-4.681	0.596	0.898	-1.886
			(0.279)	(0.486)	(3.472)	(9.583)	(5.810)	(4.943)
Competitor Proximity	Σ (Mi./100)	-	-	-	-0.143	3.400**	-2.683*	-2.594*
					(0.821)	(1.533)	(1.482)	(1.434)
Competitor Proximity^2	(Σ Mi./100)^2	-	-	-	-2.424	4.195	-2.941	-2.322
					(2.016)	(5.821)	(3.661)	(2.628)
LR Test	Chi-Square, DF	0.00, 1	0.05, 2	3.61, 3	5.05, 5		37.52, 15	
	(P-Value)	(0.974)	(0.976)	(0.307)	(0.410)		(0.001)	
Student-Level Demographic Controls		x	x	x	x	x	x	x
School Fixed Effects		x	x	x	x	x	x	x
Eligibility Class-by-Year Fixed Effects		x	x	x	x	x	x	x
School-by-Year Random Effects		x	x	x	x	x	x	x
Measurement Error Correction		x	x	x	x	x	x	x

Notes:
[1]: *, **, *** respectively denote statistical significance at the 10%, 5%, and 1% levels.

Table 5b: Coefficients of Test Scores on Competition
Student Subsample: 3rd - 5th Grade, Subject: Reading

Variable	Scale	(1) Linear Competition Intensity	(2) Prox-Weighted Intensity	(3) Quadratic Competition Intensity	(4) Prox-Weighted Polynomial	(5) Low Eligibility	(5) Medium Eligibility	(5) High Eligibility
Competitor Capacity	Σ (Int/1000)	-0.164 (0.156)	-0.388 (0.295)	-0.103 (0.381)	-0.318 (0.614)	1.151 (1.164)	0.459 (1.007)	-2.956** (1.269)
Competitor Capacity^2	(Σ (Int/1000))^2	-	-	-0.514 (0.439)	0.373 (1.533)	0.296 (3.729)	-0.827 (2.490)	4.894** (2.446)
Capacity * Proximity	Σ ((Int/1000)*Mi./100)	-	-0.217 (0.242)	-0.626 (0.425)	1.040 (3.011)	3.941 (8.325)	-1.257 (5.107)	7.519* (4.392)
Competitor Proximity	Σ (Mi./100)	-	-	-	-0.269 (0.724)	0.757 (1.378)	-0.932 (1.324)	-2.458* (1.300)
Competitor Proximity^2	(Σ Mi./100)^2	-	-	-	0.747 (1.752)	3.507 (5.060)	-2.113 (3.251)	3.002 (2.328)
LR Test	Chi-Square, DF (P-Value)	1.10, 1 (0.294)	1.90, 2 (0.387)	3.26, 3 (0.353)	3.64, 5 (0.602)		20.99, 15 (0.137)	
Student-Level Demographic Controls		x	x	x	x	x	x	x
School Fixed Effects		x	x	x	x	x	x	x
Eligibility Class-by-Year Fixed Effects		x	x	x	x	x	x	x
School-by-Year Random Effects		x	x	x	x	x	x	x
Measurement Error Correction		x	x	x	x	x	x	x

Notes:
[1]: *, **, *** respectively denote statistical significance at the 10%, 5%, and 1% levels.

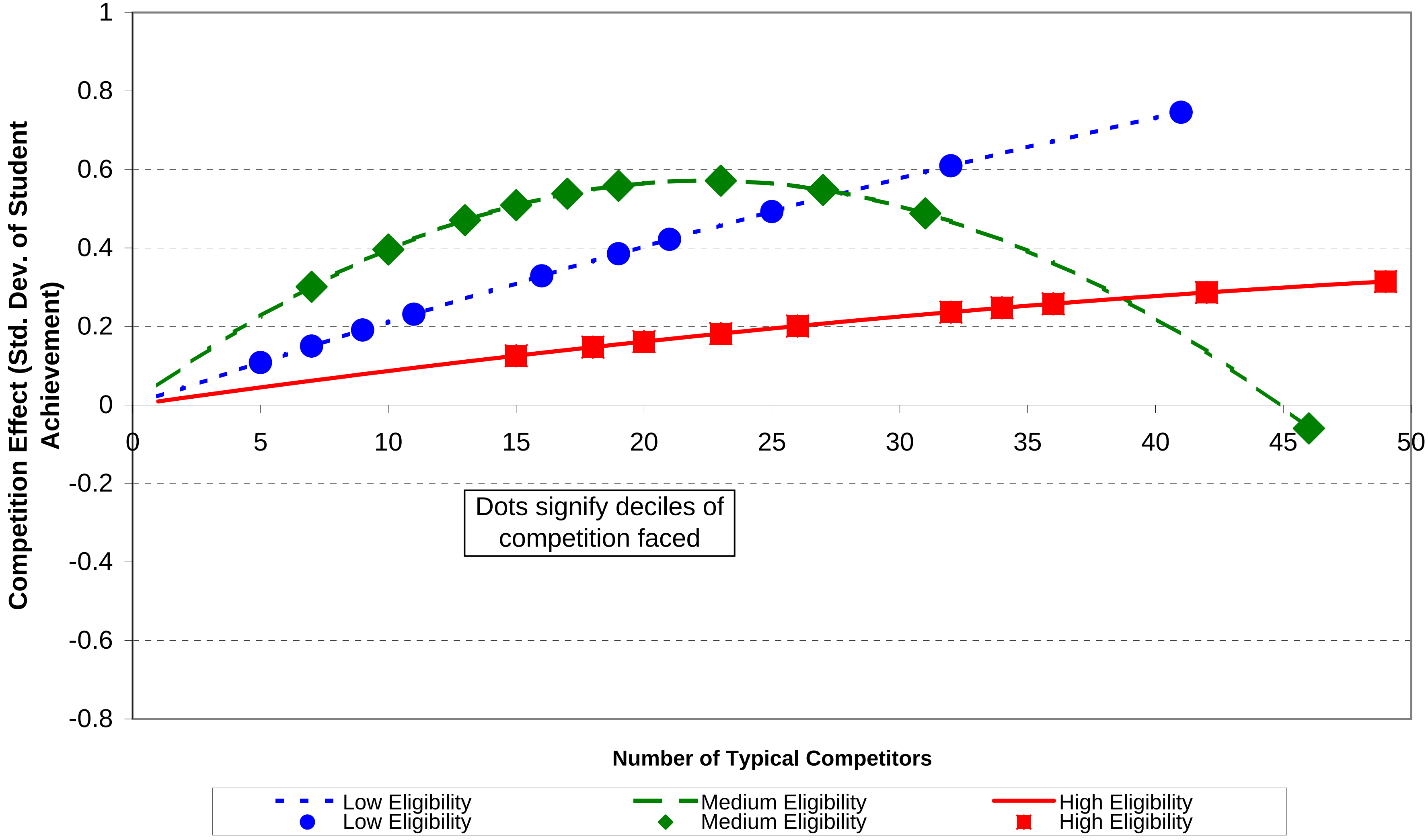
Table 6: Estimated Average Treatment Effect of Competition

Eligibility Class	Math	Reading
Low Eligibility	0.405 (0.261)	0.104 (0.234)
Medium Eligibility	0.467** (0.210)	0.235 (0.188)
High Eligibility	0.111 (0.362)	-0.252 (0.324)

Table 7: Characteristics of the Typical Competitor

Number :	1 School
Proximity :	2.0 Miles Away
Total Enrollment :	16.3 Students/Grade
Total Building Capacity :	18.6 Seats/Grade

Figure 3a. Estimated Total Effect of Competition Capacity Regression, Math



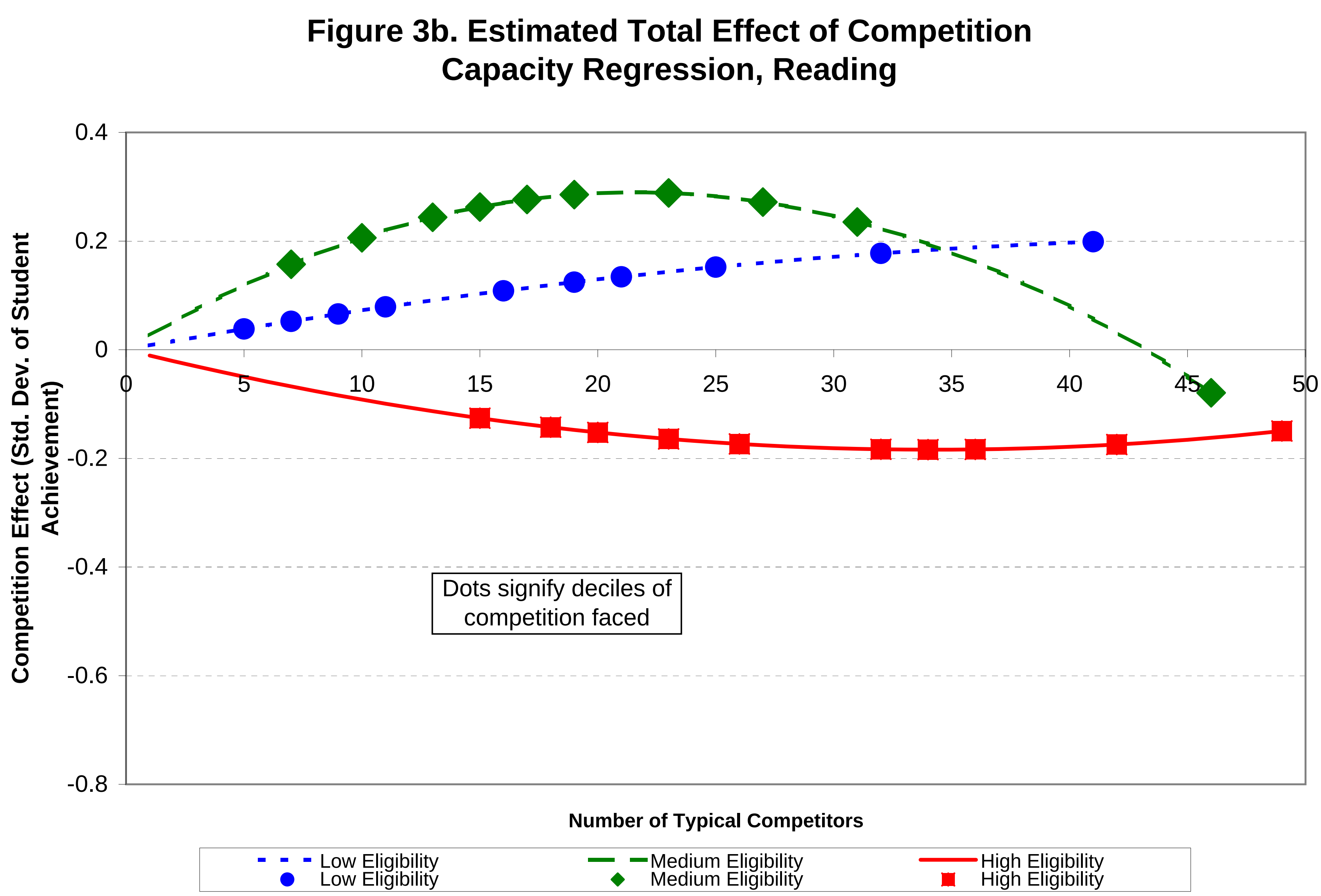
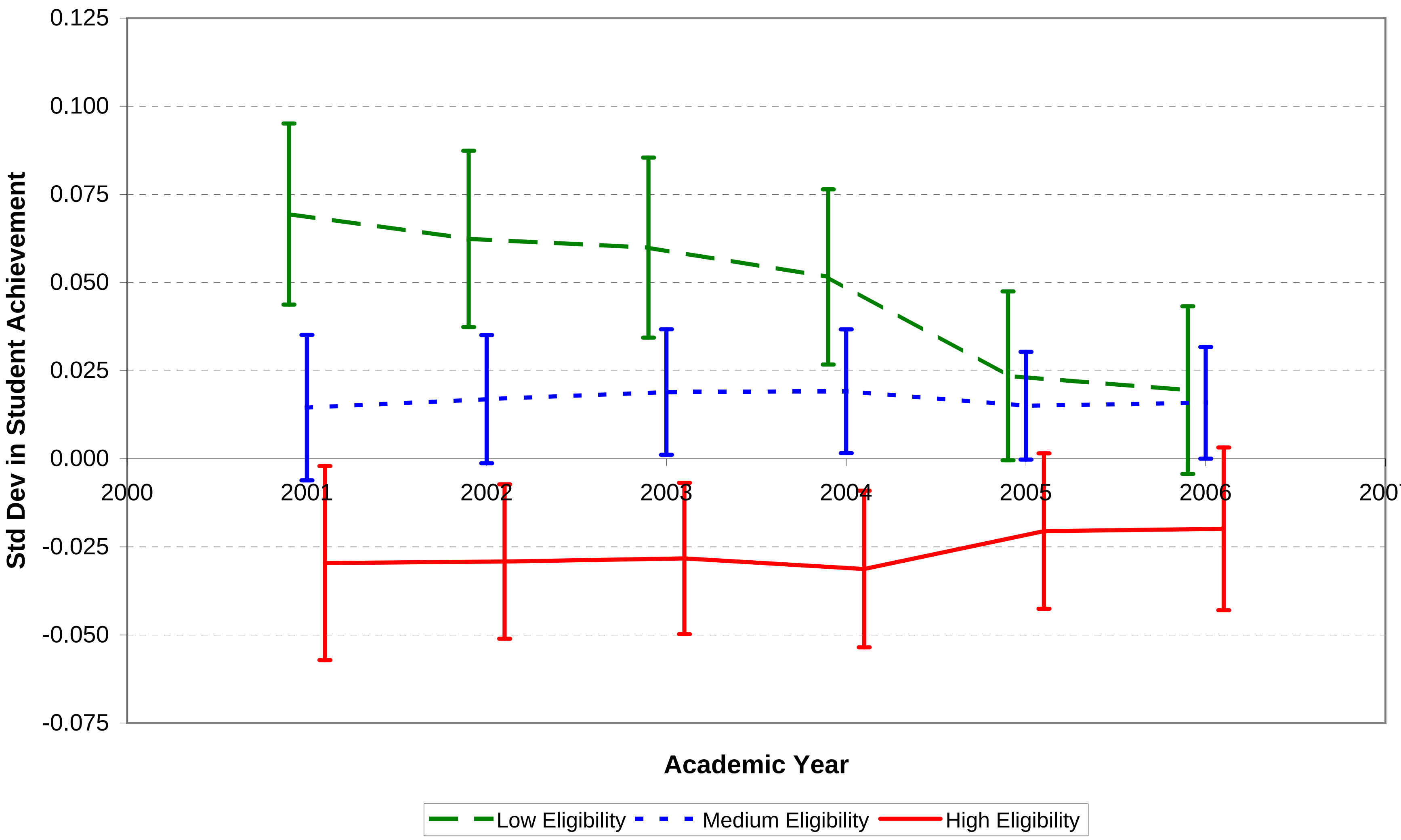


Figure 3b. Estimated Total Effect of Competition
Capacity Regression, Reading
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
20
25
30
35
40
45
50
Competition Effect (Std. Dev. of Student Achievement)
Dots signify deciles of competition faced
Number of Typical Competitors
Low Eligibility
Low Eligibility
Medium Eligibility
Medium Eligibility
High Eligibility
High Eligibility

Figure 4a. Effect of Added Competitor by Time Based on Capacity Regressions, Math



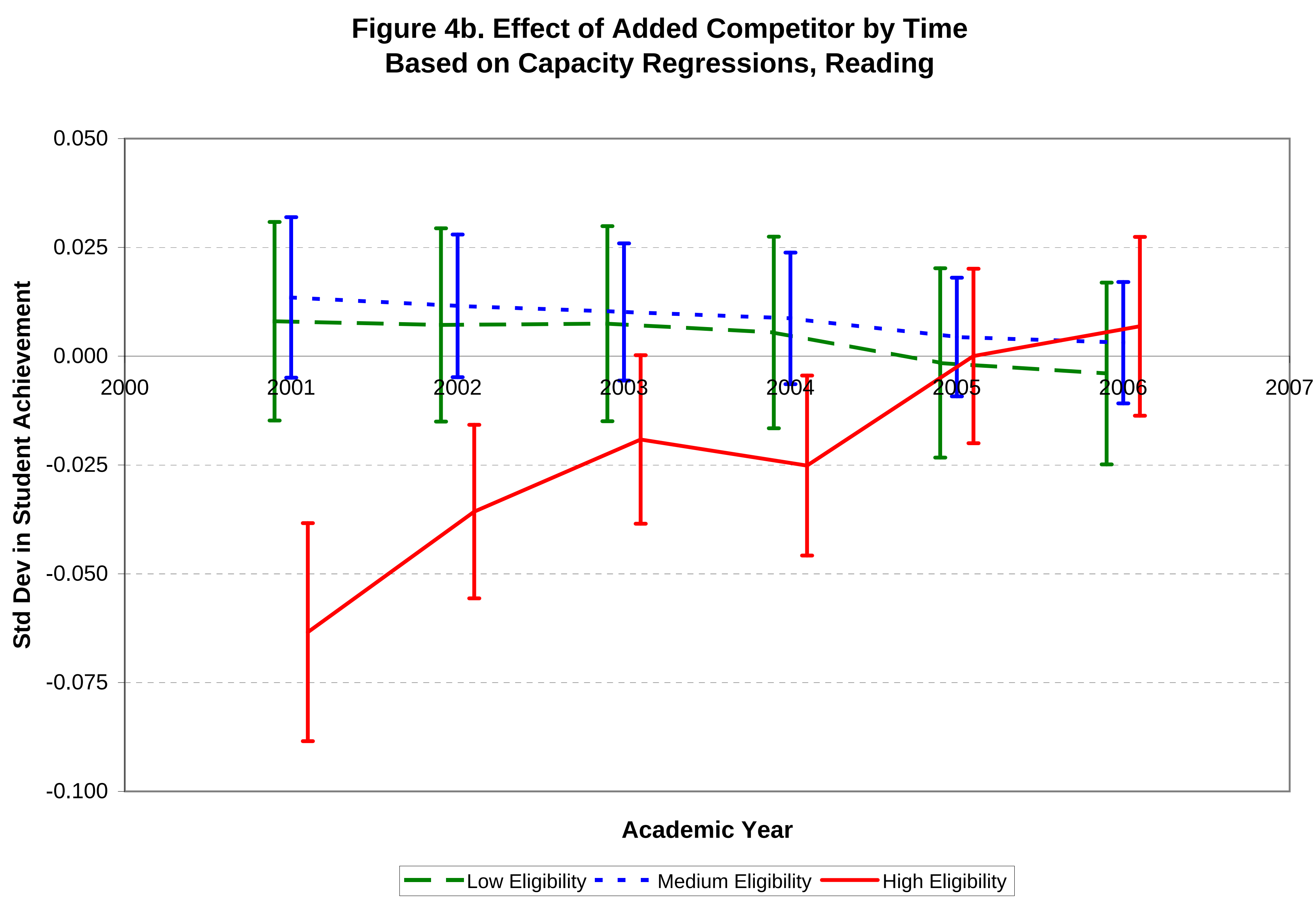


Figure 4b. Effect of Added Competitor by Time
Based on Capacity Regressions, Reading
Std Dev in Student Achievement
0.050
0.025
0.000
-0.025
-0.050
-0.075
-0.100
2000
2001
2002
2003
2004
2005
2006
2007
Academic Year
Low Eligibility
Medium Eligibility
High Eligibility