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Does competition improve public school efficiency? A spatial analysis

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ABSTRACT

Advocates for educational reform frequently call for policies to increase competition between schools because it is argued that market forces naturally lead to greater efficiencies, including improved student learning, when schools face competition. Researchers examining this issue are confronted with difficulties in defining reasonable measures of competition within local educational markets. We approach the problem through the application of Geographical Information System (GIS) tools to the development of a school competition index (SCI) for the state of Mississippi. The SCI captures the degree of competition each public school in the state faces from peer private schools spatially located within their local market area. We find that higher degrees of competition from private schools significantly increase public primary and high school efficiency, as measured by the proficiency rates on high-stakes examinations. It is anticipated that the current results will inform policymakers regarding the viability of competition-based reforms.

1. Introduction

Microeconomic theory implies that competition increases market efficiency. This should hold for all markets, including the market for education. We test this idea which is often cited by policy makers seeking educational reform. In the United States, where public school students lag behind those in other countries in standardized achievement scores, there is a sense that educational outcomes need improvement. Many believe that American public schools are inefficient, which limits their ability to improve academic outcomes (Hanushek & Woessmann, 2009). In response to such perceived inefficiency, some policy makers and economists propose a greater role for school choice and competition.

Belfield and Levin (2002) discuss two types of educational reforms: high-stakes tests and market-type reforms. The goal of the former is to increase the measured achievement levels of students, while increasing the number of available school choices by introducing voucher programs and tuition tax credits is the primary objective of the latter (Blair & Staley, 1995). Most market-type reforms allow students to attend public schools in the district where they reside, but also provide an option for them to attend private schools at reduced costs. In turn, the promotion of private schools generates market-based competition for local public schools.

Research has yielded mixed results on the effect of such inter-school competition on public school performance. Several economists have attempted to quantify the impact of private schools on public school student outcomes, but reach different conclusions. For example, Hoxby (1994),

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Couch, Shughart, and Williams (1993), and Greene and Kang (2004) find that public versus private school competition significantly increases public school outcomes; conversely Heish and Urquiola (2003), McMillan (2000), Simon and Lovrich (1996), Sander (1999), and Newmark (1995) fail to find such a relationship. Thus, further research in this area is required to provide more definitive information to policy makers and educational leaders for the purpose of future policy initiatives.

Most of the previous research employs some form of student achievement to measure the performance of public schools, but there is no consistency in identifying the specific output. There are two fundamental concerns with the identification of output. The first is that the level of observation, such as state, county, school district, or city, is not adequate to disaggregate the extent to which certain factors contribute to the efficiency of a given *school*. The second is the output measurement itself. Standardized scores in mathematics, reading or language are the most commonly used measure of student achievement. Proficiency scores which capture a previously defined level of competency are not often employed but provide a significantly narrow measurement and a better proxy of *school* quality relative to meeting overall student achievement targets.

Because inter-school competition has resulted in public controversy, measuring the effect of competition is the primary motivation for this paper. It is unclear how private schools affect public schools because it is difficult to measure the *degree of competition* across educational markets. Previous authors have employed several proxies to capture the degree of inter-school competition, but none of their techniques successfully reveal full information as they fail to include many observable attributes of a market.

The most frequently used computational techniques include the Herfindahl–Hirschman Index (HHI) (Borland & Howsen, 1993), the percentage of all students in private schools (Jepsen, 2002; McMillan, 2000), grade-specific enrollment (Geller, Sjoquist, & Walker, 2006), and market share held by private schools (Arum, 1996). Each of these techniques is problematic as market share is just one aspect of overall market attributes. Importantly, all of these techniques rely on student enrollment numbers, which are not precise estimates for competitiveness, as the level of private school enrollment is correlated with many other factors, such as community wealth or religiosity (Belfield & Levin, 2002). Furthermore, comparing a public school's local market share of student enrollment may not provide actual school competitiveness, as all public school markets are, by law, geographically bounded by district lines drawn by a political process. Before investigating the effect of competition on educational quality, it is essential to identify an effective measure of school competition.

Defining the market size and including different market attributes in the analysis is the primary agenda for this paper. Employment of a Geographical Information System (GIS) approach provides a unique way to measure the degree of competition between the public and private schools. *A review of the literature indicates that this paper is the first research to accommodate three major components of market competition: the number of competitors, the size of competitors, and the geographical distance among competitors.* Most of the previous research used competition variables employing either one or two of these three components.

A stochastic frontier approach is used to model Mississippi public schools and to estimate the technical efficiency of educational production. Then, we analyze the relationship between private competition and public school efficiency in Mississippi. This research contributes to the development of a research design that attempts to isolate competitive effects that have been difficult to quantify thus far. Therefore, examining unique *school level data* instead of state, county or district level data should provide evidence that has policy implications for the improvement of public education.

We control for factors, such as students' race and their socio-economic background, teachers' education, race, gender and experience, staffs' race and gender, principals' race, and gender, and school location which may influence school efficiency in addition to competition. The demographic composition of the public school student body is an important factor that influences private school choice. Research has shown that a school's racial and socio-economic compositions are important determinants of student achievement. For example, numerous research articles on school demographic composition and student achievement in public schools, find that schools with higher numbers of white students relative to black students leads to an increase in African American students' educational attainment (Braddcock & Eitle, 2004; Schofield, 1995; Schofield & Hausmann, 2004).

Fairlie (2006) and Epple and Romano (1998) find that racial disparities among private and public schools continue to exist, and that private school tuition credit or voucher programs lead to a greater degree of segregation, as parents enroll their children in racially homogeneous schools rather than racially heterogeneous schools. In this way, school choice and social cohesion are linked. Hence, it is important to account for the level of racial sorting between private and public schools in Mississippi. The impact of a student's demographic composition on school quality is an empirical question and measuring the effect of market competition on public school efficiency and performance would be incomplete without taking this factor into account.

Hanushek (1998,1999), Hoxby (2002) and Ching (2000) confirm that students' socio-economic characteristics significantly influence cognitive and academic abilities which increase schools' overall performance. To accommodate students' socio-economic background this analysis controls for the number of students receiving a federally sponsored free lunch in a school. The federal free lunch program is a frequently employed proxy of economic status, because eligibility depends on the level of family income (Ching, 2000; Geller et al., 2006). Student's socio-economic status is used to account for the home environment. Low income students are often exposed to abnormal environments, such as poverty, abandonment or foster care. Failure to account for such factors may reduce the explanatory power of the empirical model. There are other variables, such as parents' education, parents' marital status, number of siblings and students' extracurricular activities that should have a positive impact on student achievement, but such variables are often not readily available at a micro-level.

The public school policy debate becomes more complicated when educational researchers attempt to compare rural and urban school performance. Not surprisingly, researchers find differences in academic outcomes between these two types of schools. For example, Snyder and West (1992) and Alspaugh (1992) find that urban or metropolitan students' mathematics, reading, and science scores are better than those of rural students. However, Alspaugh and Harting (1995) and Haller, Monk, and Tien (1993) show that rural students perform better than urban students on these tests. Differences in the availability and use of resources in urban versus rural schools may contribute to differences in achievement. Coe, Howley, and Hughes (1989a, 1989b) have argued that, with fewer available resources, rural schools often limit their curricula. Kleinfeld, McDiarmid, and Hagstrom (1985), however, show that differences in the availability of resources among comparable schools do not make any difference in students' academic achievement.

With respect to geographic location, a group of public policy researchers has stated that rural schools are not efficient because either they do not use their resources efficiently, or they have insufficient inputs to produce higher quality output (academic attainment) (Kantabutra & Tang, 2006; Reeves & Bylund, 2005). The availability of a school location variable at the individual school level is the major concern behind the lack of evidence in recent urban–rural school research. Hence, this paper will contribute evidence to the current research by adding a school-specific location variable.

Most believe that human capital held by schools' workers matters. There are three types of school workers: principals (administrators), staff (non-teaching) and teachers. The sources of human capital for these workers are the same: education and experience. The human capital held by school workers may not affect students' performance, hence schools' technical efficiency, in similar ways. The importance of teachers for students' performance is greater than that of principals and staff because teachers are directly delivering their school's curriculum. Many studies document that teachers contribute to their students' academic growth, but have not been very successful in identifying the qualities of a good teacher. Judging a teacher's quality by educational attainment, experience or certification is problematic (Hanushek, 2006). Many studies have examined this issue, but the results are often contradictory and the conclusions weak. For example, Melvin and Sharma (2007) find a positive association between teacher experience and student's academic performance, but Cho (2009) fails to find this relationship. This paper attempts to find the associations between teacher quality and student academic performance. In addition to that we also examine the role of principals and staff on school efficiency.

The remainder of the paper proceeds as follows. Section 2 presents background literature on competition. Section 3 examines the methodology and data used in the study, while Section 4 presents the empirical results. Section 5 concludes the paper with a discussion of policy implications and recommendations for future research.

2. Competition studies in education

Competition from private schools may influence public schools in several ways, but most importantly effect costs and enrollments. A significant amount of research has been conducted to investigate the impact of competition on public school *academic* outcomes and school *efficiency*. There are a significant numbers of studies reporting the effect of competition on public school performance as statistically significant and positive; but there are some studies that argue against such evidence. It is important to note that both of these groups use various methodologies to measure the degree of competition.

Rhoades (1993) employs the HHI to measure the degree of competition between schools. The HHI is a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers. The measurement is bounded between 0 and 1. A higher number in the HHI indicates less competition and, hence, higher market power, while a smaller number indicates the opposite. In the U.S. education market, the average value for HHI is 0.35, and, on average, elementary schools experience more competition than secondary schools (Belfield & Levin, 2002). A range of studies has employed the HHI as a proxy for competition, but the findings are inconsistent. Borland and Howsen (1993) find that the effect of competition is positive for public school performance, but Hanushek and Rivkin (2003) find that the effect is insignificant. Marlow (2000) reports mixed results. He shows that competition at the eighth grade level increases public school outcomes, but this result does not hold for the tenth grade.

Instead of using the HHI as a competition measure, some studies apply measures of private school enrollment as a proxy. Using county-level data, Couch et al. (1993) and Newmark (1995) find that private school enrollment is positively related to public school students' standardized scores. In contrast, Geller et al. (2006) and Simon and Lovrich (1996), use district-level data, find that private school enrollment has no effect on public school student performance.

Other measures, such as the total number of schools or school districts per 1,000 students, have been used as an alternative to HHI. Using this approach, Marlow (1997) determines that the effect of competition varies across grade levels. Another approach is to use instrumental variable (IV) techniques, where an instrumental variable is correlated with private school outcomes, but uncorrelated with the error term in the model. Among recent studies in education, Hoxby's (2002) contribution is notable. Hoxby uses an IV approach to measure the effect of competition, employing family income as an instrument and finds a significant positive relationship between private school competition and public school outcomes.

There are several limitations to these studies. First, they suffer from inadequate definitions of the educational market because most use state, county, school district, or individual student levels of observation. These units of observation, in general, suffer from estimation issues such as aggregation bias.[3] The results from the aggregate level may not reveal correct information on the individual school level, and policy prescription based upon these results may not be appropriate. To analyze *school* performance in the education market, one needs to use *school* level data instead of school district or county data.

The second concern is how to compute the competition variable. The HHI, private school enrollment, or instrumental techniques, are acceptable methods to measure the effect of competition in the education market, but all are indirect approaches. Most previous studies use a market share approach to quantify market power, but the education market is a unique one in which the industry or consumer market setting does not work very well. A school's performance (output) is measured by students' academic outcomes, which are hard to quantify in market share terms. Earlier researchers have followed the traditional market structure theory to define the educational market by assuming that it is bounded within a school district, but in reality, a public school can face competition from private schools within the district or from adjoining school districts, as private school parents can easily cross the district, county, or even state boundaries for their children's education. By redefining the market at the school level the current empirical model will provide better and more precise information about competition on public school performance.

3. Methodology and data

To examine the relationship between competition and technical efficiency, a two stage stochastic frontier process is employed. In the first stage, a production frontier is estimated as described in Kumbhakar and Lovell (2000) using a half-normal distribution. This production frontier relates some measure of school output to a set of inputs from each school. The frontier also gives estimates for technical efficiency for individual schools. These estimates of technical efficiency are then used as a dependent variable in a regression with school competition and other factors as explanatory variables.

In education studies, previous authors employed various mixes of inputs and outputs, such as one input–one output, multiple inputs–one output and multiple inputs–multiple outputs to estimate technical efficiency. Following Kantabutra (2009), we employ a multiple inputs–one output formulation in the production function to estimate individual school efficiency. A stochastic frontier model, following Aigner, Lovell, and Schmidt (1977) and Meeusen and Van den Broeck (1977), is used to estimate technical efficiency.

In the stochastic frontier approach, as described by Kumbhakar and Lovell (2000), the following production frontier is estimated for the schools in the sample:

$$y_i = f(x_i, \beta) \cdot TE_i \tag{1}$$

where y_i is a scalar measure of output for school i, $i = 1, 2, \ldots, I$, x_i is a vector of N inputs. β is the technical parameter which will measure the school specific technical efficiency. TE is the maximum feasible score that one school can achieve from this production set and it is $TE_i = 1$, and anything less than one will be the estimate for the short fall of technical efficiency.

After converting a Cobb–Douglas production function into a log-linear function, the stochastic frontier model representation would be as follows:

$$\ln y_i = \ln f(x_i, \beta) + v_i - u_i \tag{2}$$

where v_i is the noise factor and u_i is the nonnegative technical inefficiency part of the frontier analysis. A number of previous literatures used this approach to predict the technical efficiency and then used this variable in the second stage regression as a dependent variable to determine the reasons for differing efficiencies.[4]

3.1. Measuring school competition

We include the constructed school competition index (SCI) as an exogenous factor in the second stage of the stochastic frontier model. An exogenous factor is defined as an outside factor which can affect output, and hence, efficiency. Several authors for example, Borland and Howsen (1993), Jepsen (2002), and McMillan (2000) have pointed out that private school competition is an exogenous factor which influences public school performance, but a general conclusion about the effect of competition is still missing as the definition of a school market is highly controversial.

The traditional definition of market structure is not sufficient to reveal the strength of market competition.[5] In addition to the number of competitors, knowing the size of competitors and distance between them is important to measure the competitive pressure. Therefore, a new methodology is needed to measure the competition more accurately than before. We follow the similar methodology as Misra and Chi (2011) to develop the competition index for this paper.[6] The following formulation

$$A_i = \frac{1}{E_i} \sum_{j \neq i} E_j d_{ij}^{-2}, \tag{3}$$

where E_i is enrollment of a public school, E_j is the private school enrollment, d is the distance between the public and private school (i and j denotes public school and private school respectively) that we have used to develop the school competition index for a public school. We draw different circles to define the different size of a market, such as 5 mile, 15 mile, or 25 mile radius around each public school. Then we count the number of private schools, their total enrollment and the distance among them inside

[3] "An aggregated view can suggest homogeneity within a group that is actually composed of distinct sub-groups. In other words, it can fail to acknowledge discrete differences." (Birks, 2003)

[4] As noted by Simar and Wilson (2007), there are correlation problems with the two stage approach. However this approach seemed appropriate, as it permitted the estimation of the relationship between efficiency and competition.

[5] Number of competitors in a market (Glenn & Anthony, 2010, chap. 11, p. 378).

[6] Please see Misra and Chi (2011) for further discussion.

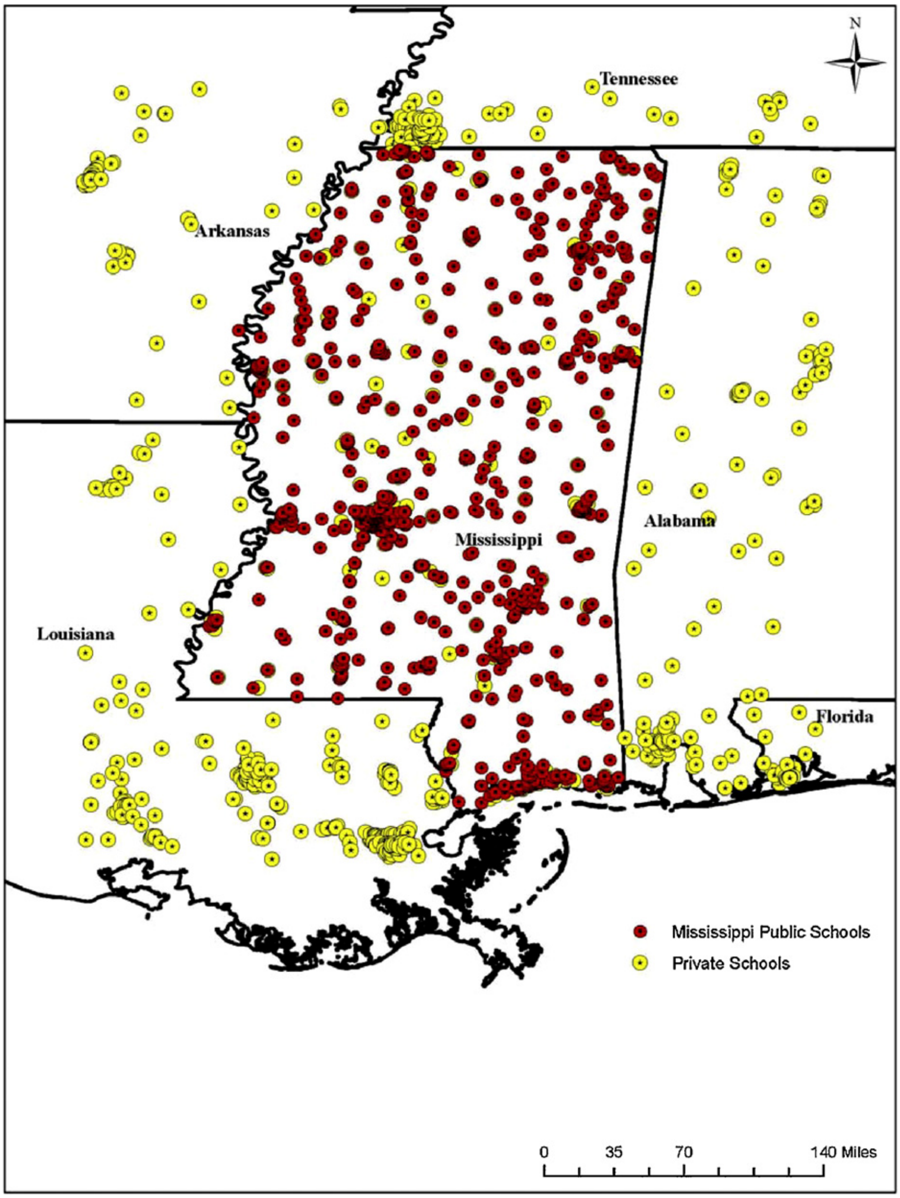

Fig. 3.1. Public and private schools in Mississippi and private schools in neighbor states.

that circle (Misra & Chi, 2011).[7] Competition from private schools not only comes from the same state but it can come from neighboring states in border areas such as Alabama, Tennessee, Louisiana, and Arkansas.[8] To accommodate this fact we include these states in the GIS model (Fig. 3.1). Please see Figs. 3.2 and 3.3 for spatial representation of the school competition indices for Primary Schools and High Schools.[9] The biggest advantage of using this index is that it is not bounded; therefore it can be treated as a continuous variable. This index follows an increasing

[7] Data on private schools quality (examination scores, curriculums) and other characteristics could be very useful to incorporate into this paper, but these information are not available for public to use.

[8] Competition from charter schools and home schooling were not part of the analysis. Mississippi law on charter schools has not encouraged the formation of charter schools and there are currently none in operation. Home schooling does compete with the public schools to a degree, but reliable home schooling data for this analysis were not available.

[9] We realize the possibilities of a public school can face competition from similar public schools which are operating in the same market area. We did not account that sought of competition in this paper as unlike other state in this country the density of public schools in Mississippi is much lesser. Hence, facing competition from similar type of public schools is very negligible. Moreover, this is beyond the scope of this paper as we are trying to understand the effect of competition from private schools to public schools performance as this is the claim for educational reformers. There are only four charter schools in Mississippi and the information could be found in the following link: http://www.eot.org/charter-schools-mississippi/. But information about Charter and Home schools are not available for public to use.

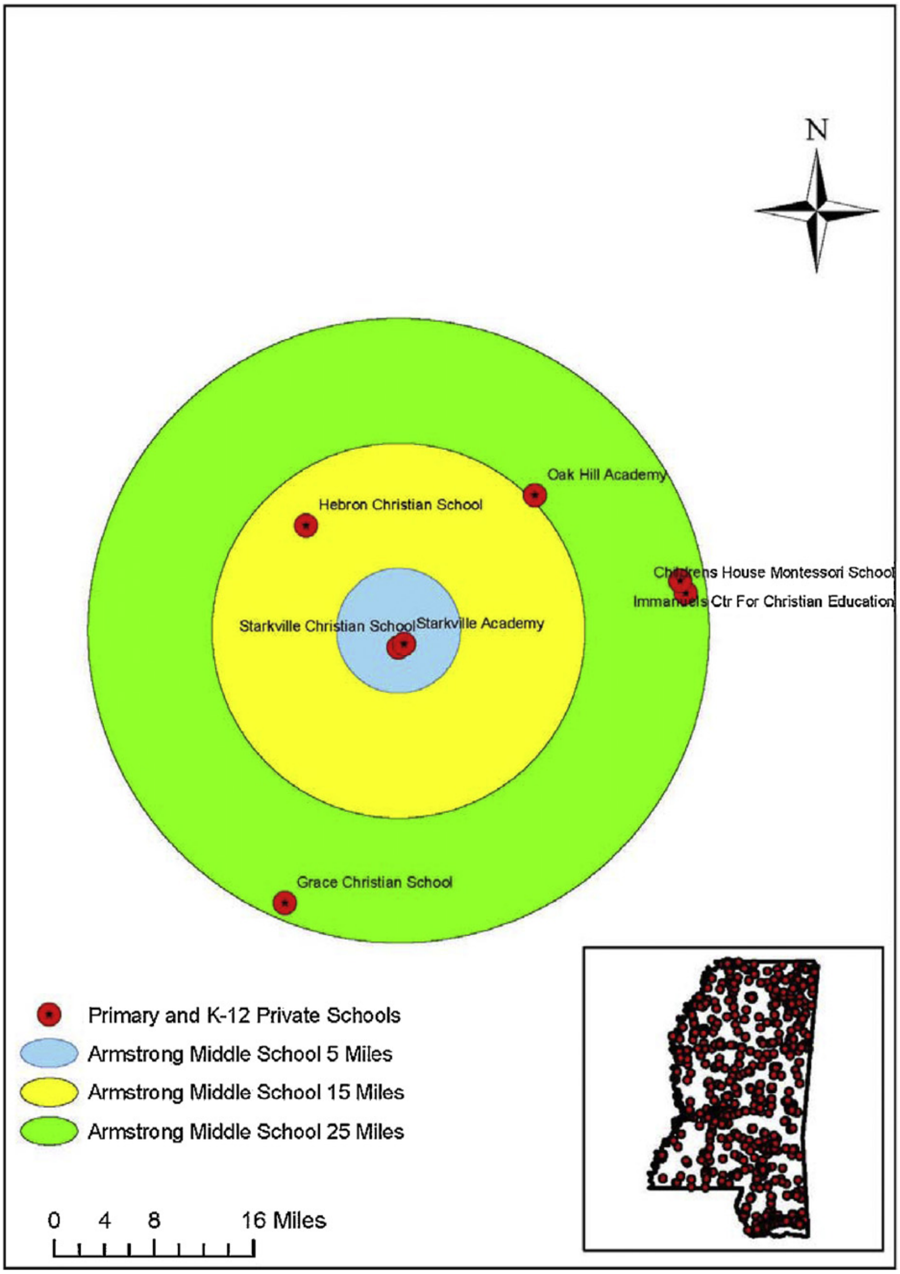

Fig. 3.2. School competition index for Armstrong Middle School, Starkville, MS.

sequence meaning 0.5 is less competitive than 1, or 2 is less competitive than 3, etc.

3.2. Data

The data used in this study are obtained from reports compiled by the Mississippi Department of Education for the academic year 2005–2006. Most of the variables are collected from the Mississippi Report Card (MRC) which is published annually by the Mississippi Board of Education. The data include the number of proficient performers on the Mississippi Curriculum Test (MCT) for Primary Schools, and Subject Area Testing Program (SATP) examinations for High Schools. Data on enrollment, students' demography, and the number of students' receiving reduced price or free lunches, are also included in the data set. Table 3.1 provides variable definitions and summary statistics.

The categorization of a school is based upon the range of grades offered by a school. Following Kantabutra (2009) we employ a multiple inputs–one output formulation in the production function to estimate the individual school efficiency. Thus, we use graduating student performance

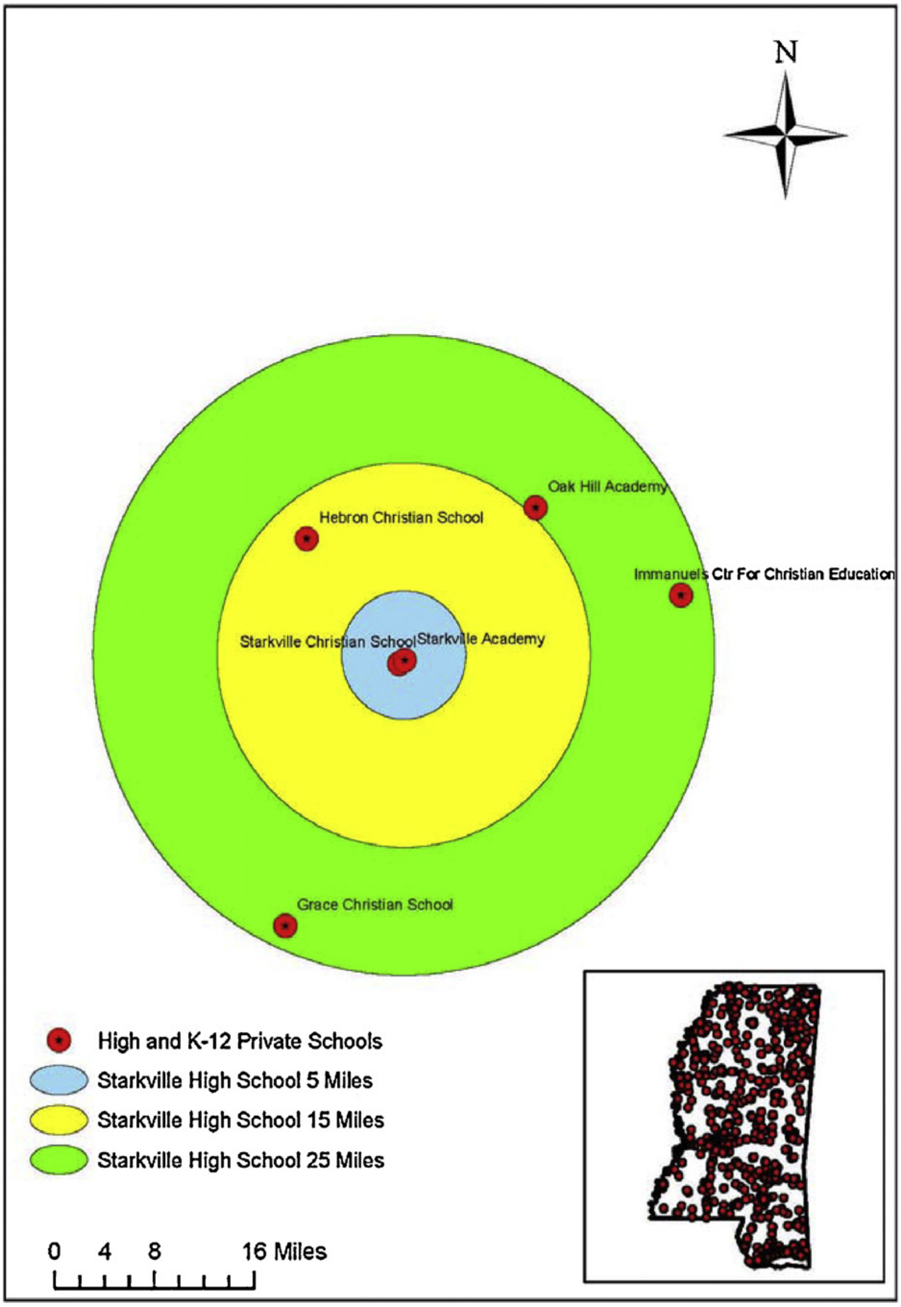

Fig. 3.3. School competition index for Starkville High School, Starkville, MS.

on standardized tests by individual school as the output. The final sample data set includes 90 Primary Schools (8th grade), and 151 High Schools in Mississippi. Efficiency should not be compared between these groupings because the required standardized tests (i.e. output) are different between grade levels. The MCT examination at the time of this data collection included three different subjects, Reading, Language and Mathematics, and the SATP examination included four different subjects, Algebra I, U.S. History, Biology I, and English II.

Following Cho (2009), we employ the proficient performers' rate from the MCT or SATP test as output.[10] For this paper we follow Marlow (1997) and Arum (1996) to select grade 8 data for Primary Schools, while for High Schools we use grade 12 data. Student performance at the

[10] The primary motivation to include proficient performers' rate as an output instead of the number of students in the production function is to incorporate student performance in the analysis.

Table 3.1
Variable descriptions and summary statistics for primary schools (8th grade) and high schools.[a]

Dependent variable	Variable definition and source	Mean (Std. dev.) 8th grade (*N* = 90)	Mean (Std. dev.) High schools (*N* = 151)
MCT Overall	Mean percent of students passed Mississippi Curriculum Test at proficient and above levels across all subjects (% of students passed MCT Reading at proficient and above levels + % of students passed MCT Mathematics at proficient and above levels + % of students passed MCT Language at proficient and above levels/3)	28.49 (7.88)	–
SATP Overall	Percent of students passed in Subject Area Test Program at proficient and above level across all subjects (percent of students passed Algebra I at proficient and above levels + percent of students passed History at proficient and above levels + percent of students passed Biology at proficient and above levels + percent of students passed English at proficient and above levels/4)	–	52.61 (14.40)
Explanatory variables			
Inputs			
School Building Areas per Student	Total area of a school in square feet/total students	142.53 (64.11)	183.41 (74.40)
General Expenditures per Student	Total general expenditure including school maintenance cost and other supplies in dollar/total students	185.39 (74.81)	287.88 (185.84)
Textbook Expenditures per Student	Total text book and instructional expenditure in dollar/total students	70.42 (59.04)	81.56 (46.42)
Students per Teacher	Mean number students per teachers in a school	13.33 (76.00)	14.64 (87.49)
Students per Staff	Mean number of student s per staff in a school	20.83 (38.46)	24.82 (76.43)
Discretionary inputs			
Principal's Race	Principal's race, dummy variable 0 = Black principal 1 = White principal	0.28 (0.45)	0.33 (0.47)
Principal's Gender	Principal's gender, dummy variable 0 = Female principal 1 = Male Principal	0.13 (0.33)	0.15 (0.36)
Staff	Mean number of staff	21.98 (10.99)	25.70 (13.04)
Staff's Race	Percentage of staff that is black (total number of black staff/total number of staff)	34.59 (32.86)	34.56 (33.70)
Staff's Gender	Percentage of non-teaching staff that is female (total number of female staff/total number of staff)	73.83 (12.08)	57.91 (12.08)
Teacher	Mean number of teachers	38.35 (17.49)	44.29 (19.79)
Teacher's Race	Percentage of teachers that is black (total number of black teachers/total number of teachers)	26 (28.49)	29 (30.75)
Teacher's Gender	Percentage of teachers that is female (total number of female teachers/total number of teachers)	82 (7.02)	33.53 (8.71)
Teacher's Experience	Mean number of years experience	12.28 (2.62)	13.24 (2.29)
Teacher's Education	Percentage of teachers with master degree (total number if master degree holder teachers/total number of teachers)	36.92 (10.52)	36.43 (10.37)
Enrollment	Mean number of students in school	608 (267)	680 (349)
Non-controllable inputs			
Black Students	Percentage of students that is black (total number of black students/total number of students)	48.43 (34.08)	53.29 (33.46)
Free Lunch Program Students	Percentage of students receiving free lunch (total number of students receiving free lunch/total number of students in a school)	64.14 (22.95)	60.42 (23.82)
Exogenous factors			
Small-city/rural	School Location Dummy 0 = urban fringe of a mid-size city, urban fringe of a large city, mid-size city, suburb-midsize 1 = small city, large town, rural, rural inside CBSA, rural outside CBSA, rural distant, rural fringe, rural remote, small town, town remote	85 (35)	88 (32)

Table 3.1 (*Continued*)

Dependent variable	Variable definition and source	Mean (Std. dev.) 8th grade (N = 90)	Mean (Std. dev.) High schools (N = 151)
School Competition Index	School competition index computed from total number of private schools using gravity access model $\left(A_i = 1/E_i \sum_{j \neq i} E_j d_{ij}^{-2}\right)$ around		
	5 miles of a public school	0.52	0.16
		(1.18)	(0.52)
	15 miles of a public school	0.54	0.17
		(1.82)	(0.53)
	25 miles of a public school	0.56	0.18
		(1.83)	(0.53)

Source: Dependent variables, inputs variables, discretionary inputs variables, non-controllable inputs variables – Mississippi Department of Education, National Center for Education Statistics (NCES), The Northeast Regional Center for Rural Development, and Mississippi Department of Education and National Center for Education Statistics (NCES).

[a] This is a subset of the total public schools in Mississippi which include 8th grade and high public schools.

graduating grade in a school should capture the overall learning experience and accumulated analytical, mathematical, and comprehensive skills. In this paper we use the graduating score from overall educational performance as output. The overall education performance is the average score of Reading, Mathematics and Language examinations for Primary Schools and Algebra, History, Biology and English examinations for High Schools respectively. The average overall proficiency rates for these examinations are 28.49 for grade 8 and 52.61 for High Schools.

School geographical location and the school competition index are used in this paper as exogenous factors. 85% of the total Primary Schools and 88% of total High Schools are located in small-city/rural areas. We use markets with a 5 mile radius, 15 mile radius, and 25 mile radius for this study to measure the degree of competition for public schools. Therefore, the mean for these exogenous variables varies with the market size employed. The mean school competition index variable ranges from 0.52 (5 miles) to 0.56 (25 miles) with a minimum and maximum values 0 to 11.04 for Primary Schools and from 0.16 (5 miles) to 0.18 (25 miles) with a minimum and maximum values 0 to 4.10 for High Schools in Mississippi. Hence, a public school with a larger defined market would have a higher competition index.

4. Results

Following Aigner et al. (1977) and Meeusen and Van den Broeck (1977), maximum likelihood estimation is employed to estimate the parameters of a stochastic production frontier and then used to examine the factors contributing to this inefficiency.

The school-level analysis uses the percentage of proficient performers, based on the MCT and SATP Overall examinations in 8th grade and High Schools respectively, as a dependent variable, which is a proxy for Primary School and High School output. Input variables, including capital (building area, general expenditures and textbook expenditures per student) and labor (number of teachers and instructors per student), are included in the production frontier model.

4.1. Stochastic frontier results: primary schools and high schools

We present the stochastic frontier results in Table 4.1. These results are based on students' performance in 8th grade, using the MCT Overall scores. It is clear from this table that some of these inputs are significantly associated with output. The building area per student and general expenditures per student are significant and positively related with a school's MCT Overall proficiency rate, but only general expenditures per student is significant for High Schools. Thus, higher levels of general expenditures increase Primary School and High School student performance. School space is also a significant input for Primary Schools. The textbook expenditures and number of teachers and staff variables are insignificant. Hence, increasing textbook expenditures and hiring more teachers and staff will not increase the number of proficient performers in public schools in Mississippi. Technical

Table 4.1
Results from stochastic frontier analysis for 8th grade and high schools.

Variables/dependent variable	Log MCT Overall (8th grade)	Log SATP Overall (High School)
Constant	2.36***	3.73***
	(0.45)	(0.41)
Log of Building Area per Student	0.24**	−0.04
	(0.13)	(0.04)
Log of General Expenditures per Student	0.26**	0.09***
	(0.12)	(0.04)
Log of Textbook Expenditures per Student	−0.05	0.03
	(0.05)	(0.02)
Log of Number of Teachers and Staff per Student	−0.25	−0.08
	(0.24)	(0.09)
Log likelihood function	−6.57	−13.71
Technical efficiency		
Mean	0.75	0.78
Min	0.28	0.69
Max	0.97	0.97

N = 90 and 151.
Standard errors are in parenthesis.
*Statistical significance at 10%.
** Statistical significance at 5%.
*** Statistical significance at 1%.

Table 4.2
Determinants of efficiency: 8th grade primary schools.

Variables	8th grade coefficient (Std. error) $N = 90$ 5 miles	8th grade coefficient (Std. error) $N = 90$ 15 miles	8th grade coefficient (Std. error) $N = 90$ 25 miles
Dependent variable: Inefficiency Score in Proficient Rate			
Independent variables			
Constant	−0.07	−0.05	−0.03
	(0.33)	(0.33)	(0.33)
Black Principal	0.07*	0.07*	0.07*
	(0.04)	(0.04)	(0.04)
Female Principal	0.00	0.00	0.00
	(0.03)	(0.03)	(0.03)
Experience Principal	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)
Square Experience Principal	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)
Percent of Black Staff	0.02	0.03	0.04
	(0.13)	(0.13)	(0.13)
Percent of Female Staff	0.10	0.10	0.11
	(0.12)	(0.12)	(0.12)
Percent of Black Teachers	0.08	0.05	0.05
	(0.14)	(0.14)	(0.14)
Percent of Female Teachers	−0.55***	−0.55**	−0.57***
	(0.21)	(0.21)	(0.21)
Percent of Master Teachers	−0.01	−0.01	−0.01
	(0.12)	(0.12)	(0.12)
Experience Teachers	0.03	0.03	0.03
	(0.04)	(0.040)	(0.04)
Square Experience Teachers	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)
Percent of Black Students	0.45***	0.46***	0.46***
	(0.08)	(0.07)	(0.08)
Percent of Free Lunch Students	0.29***	0.29***	0.28***
	(0.07)	(0.07)	(0.06)
Small-city/rural	0.04	0.04	0.05
	(0.03)	(0.03)	(0.03)
School Competition Index	−0.03***	−0.03***	−0.03***
	(0.01)	(0.10)	(0.01)
Adj-R-square	0.89	0.89	0.89

Heteroskedasticity corrected model.
* Statistical significance at 10%.
** Statistical significance at 5%.
*** Statistical significance at 1%.

efficiency is reported in the last row of this table. On average, Mississippi 8th grade public schools are 75% and High Schools are 78% efficient, respectively.

4.2. *Factors related to inefficiency: primary schools and high schools*

In Table 4.2 we report the Primary School regression results. The variable for black principal, the percent of female teachers, the percent of free lunch students, the percent of black students, and the school competition index all have a significant relationship with Primary School inefficiency. All other variables are insignificant in this model.

The model was also estimated for the sample of High Schools, with results reported in Table 4.3. The significant variables for the High School sample are female principal, principal experience, percent of female teachers, percent of master teachers, percent of black students, and the school competition index. The remaining variables were insignificant.

The main hypothesis of this paper addresses the relationship between competition and inefficiency. Competition from private schools is found to have a significant and negative relationship with public school inefficiency. This result is found for both Primary and High Schools. On average a unit increase in the school competition index value will decrease inefficiency by 0.03 units for Primary Schools and 0.06 units for High Schools. Hence, higher competition is associated with increased public school efficiency, which provides sufficient evidence to reject the null hypothesis. This result supports the previous work of Hoxby (1994), Couch et al. (1993) and Greene and Kang (2004).

While not part of the main hypothesis, the results for the other explanatory variables are instructive. We examine the relationship between human capital and schools' technical inefficiency and in Primary Schools, black principal and the percent of female teachers variables are significant (Table 3.1). Hence, in Primary Schools, the degree of human capital (experience and education) held by the chief administrator (principal) and teachers has no effect

Table 4.3
Determinants of efficiency: high schools.

Variables	High schools coefficient (Std. error) $N = 151$ 5 miles	High schools coefficient (Std. error) $N = 151$ 15 miles	High schools coefficient (Std. error) $N = 151$ 25 miles
Dependent variable: Inefficiency Score in Proficient Rate			
Independent variables			
Constant	0.08	0.09	0.09
	(0.16)	(0.16)	(0.16)
Black Principal	−0.00	−0.00	−0.00
	(0.03)	(0.03)	(0.03)
Female Principal	0.05**	0.05**	0.05**
	(0.02)	(0.02)	(0.02)
Experience Principal	−0.00*	−0.00*	−0.00*
	(0.00)	(0.00)	(0.00)
Square Experience Principal	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Percent of Black Staff	0.03	0.04	0.04
	(0.08)	(0.08)	(0.08)
Percent of Female Staff	0.01	0.01	0.01
	(0.05)	(0.06)	(0.06)
Percent of Black Teachers	−0.10	−0.11	−0.10
	(0.07)	(0.08)	(0.08)
Percent of Female Teachers	0.19**	0.20**	0.20**
	(0.08)	(0.09)	(0.09)
Percent of Master Teachers	−0.17***	−0.17***	−0.17***
	(0.05)	(0.05)	(0.05)
Experience Teachers	0.02	0.01	0.01
	(0.02)	(0.02)	(0.02)
Square Experience Teachers	−0.00	−0.00	−0.00
	(0.00)	(0.00)	(0.00)
Percent of Black Students	0.29***	0.29***	0.29***
	(0.05)	(0.05)	(0.05)
Percent of Free Lunch Students	−0.06	−0.06	−0.06
	(0.05)	(0.06)	(0.06)
Small-city/rural	0.01	0.01	0.01
	(0.03)	(0.03)	(0.03)
School Competition Index	−0.05**	−0.06**	−0.05**
	(0.03)	(0.03)	(0.03)
R-square	0.59	0.59	0.59
Adj-*R*-square	0.54	0.55	0.54

Heteroskedasticity corrected model.
* Statistical significance at 10%.
** Statistical significance at 5%.
*** Statistical significance at 1%.

on technical inefficiency after controlling for other factors in the model. The race and gender of principals and teachers are also important factors as they are significantly different from zero in these schools. For example, the variables black principal and the percent of female teachers are significant for Primary Schools. Hence, a black principal is found with more Primary School inefficiency, but a female Primary School teacher is associated with less inefficiency as compared to male Primary School teachers.

The results from the Primary School model indicates that the percent of free lunch students is positively related to the inefficiency score suggesting that the socio-economic status of students is related to Primary School inefficiency. This finding is similar to other studies (Adkins & Moomaw, 2007; Fairlie, 2006) where they show that students' socio-economic background is related to their academic performance. The percent of black students in a school also has a significant negative relationship with Primary School. Thus, Primary School inefficiency is higher when the percent of black students is relatively large. This result is similar to previous education studies by Ching (2000) and Dee (1998).

In this paper we employ a school location with a dummy variable for rural areas. The coefficient for this variable remains insignificant in Primary School models. Therefore, Primary School inefficiency does not depend on location. This result confirms the findings by Kleinfeld et al. (1985), but it differs from other studies. Snyder and West (1992) and Alspaugh's (1992) argue that urban public schools are better than rural public schools while Alspaugh and Harting (1995) and Haller et al. (1993) find the opposite result.

For the High School sample (Table 4.3), the discretionary variable female principal in High School is associated with more inefficiency in High Schools as this variable enters with a positive sign into the models. Another significant discretionary variable is principal's experience which enters into the models with a negative sign, indicating that an experienced principal is found in less inefficient High Schools. Therefore, regardless of a principal's gender or race, principal experience does matters.

The next two significant variables in High School models are percent of female teachers and percent of master teachers, but these variables are related to school inefficiency quite differently. The percent of female teachers variable has a positive sign, which indicates that increasing the number of female teachers in High Schools is associated with more inefficiency. On the other hand, the percent of master teachers has a negative sign; schools with a higher proportion of teachers with a master's degree are less inefficient.

Similar to the Primary School models, we employed two non-controllable variables such as student's race and their socioeconomic status in the High School Models. Student's race is not significant in any one of these models but their socio-economic status (percent of free lunch students) variable is significant in all models. Therefore, the presence of a higher percent of free lunch students in a High School is found with increased High School inefficiency after controlling all other factors in the models. This result is similar to Primary School models as well as other education studies by Ching (2000) and Dee (1998).

Comparing the results for Primary and High Schools reveals some discrepancies for characteristics of the faculty and administration. Female principal, principal experience, percent of female teachers and percent of master teachers are significant variables in all High School models but these variables are not significant in Primary School models. A possible reason for the inconsistent results is the variation in school type. Primary Schools serve an entirely different student population than High Schools. A High School serves mostly teenagers whereas a Primary School serves a more diverse age group. There are no doubts that school leadership skills matter, and male and female principals appear to manage their students differently. These leadership skills are varied in acceptance, authority, activity, and advantage among these male and female principals (Johnson, Busch, & Slate, 2008). Male principals are more directive, and authoritative whereas female principals prefer to follow a democratic style. Different styles of leadership and teaching might be associated with different levels of efficiency. In this case, male principals appear more effective in High Schools while female teachers are more efficient in Primary Schools. These results are similar to the findings of Blackmore (1989) and Haslett, Geis, and Carter (1992).

To check the robustness of this model, we employed an individual (Mathematics) subject score instead of overall score as a dependent variable and find quite similar results.[11] The competition variable comes out significant and negative for the Primary School model, but insignificant for the High School model. Although the effect of competition on public schools is the same at the overall school performance level, it is different at the individual subject level. Hence, this additional result suggests that Primary Schools are more competitive than High Schools in Mississippi.

5. Conclusions, policy issues and limitations

The purpose of this study is to examine if traditional market theory can predict whether competition increases technical efficiency in the education market. Previous research in education efficiency lacks a proper definition of a school market, and the necessary components of such markets and individual school level data to test this theory. These issues drive the interest, and provide the scope for this paper.

School building area and general expenditures are significant inputs for 8th grade Primary Schools, while general expenditures are the only significant input for High Schools. Therefore, a general conclusion about the input requirements is hard to make. After we compare these two groups of schools, we conclude that general expenditures are a crucial input for a majority of Public schools. This may be because a school's general expenditures per student can vary in a short period of time due to changes in day-to-day operating expenses. School building area per student, textbook expenditures per student and number of teachers and instructors per student are fixed inputs based on individual school demand supplied by the local government, and vary infrequently. Hence, these fixed inputs have less explanatory power in cross section analysis.

It appears that the human capital held by teachers and administrators, such as teaching experience and education attainment, are insignificant in Primary Schools, but significant in High Schools. The degree of effectiveness may have depended on the composition of the student population. High School students are mostly teenagers; therefore an effective teaching or instructional leadership style needs experienced teachers with higher levels of education. However, Primary Schools, mostly serve children where experience and higher education held by teachers and administrators might not have mattered as much for the students' academic success.

Not surprisingly, the percent of black students and the percent of free lunch enrollment variables are significant in all models. These results further confirmed previous findings that a student's family background and income are important factors for academic performance. Previous research has pointed out a number of reasons that black and poor students are at risk of poor academic performance. For example, Ching (2000) mentions that a student's cognitive abilities are related to family income and a high number of black students' families live below the poverty line in Mississippi.[12] A number of interventions can be used to improve the performance of these students, such as effective teaching, parental education, and reward programs, which will guide these students toward success.

A clear-cut conclusion about the school location effect is also not easy to draw. This variable is not significant neither in Primary Schools nor in High Schools models. Therefore,

[11] We used individual subjects (Language, Reading for Primary Schools and History, English for High Schools) as dependent variables and the results are quite similar to the Mathematics models.

[12] *Source*: State Health Facts.Org. Retrieved on April 13, 2010, from http://statehealthfactsonline.org/profileind.jsp?ind=14&cat=1&rgn=26&cmprgn=1.

it is hard to draw a conclusion from these results about the student performance gap between rural and urban schools in Mississippi.

The levels of competitive behavior are very similar between these Primary and High Schools, that is, private schools provide competition to both types of these schools. Hence, the empirical results provide strong support to the hypothesis that private school competition improves public school efficiency. This result is in support of Marlow (2000), Borland and Howsen (1993) and Hoxby's (2002) papers where they find that the presence of private schools improved the performance of Primary Schools. Moreover, this result also confirms Arum (1996) and Marlow's (1997) papers that competition from private schools increase student academic outcomes in High Schools. Hence, the effect of competition does increase school technical efficiency or academic outcomes but a proper definition of a market is needed to be laid out before estimating the market efficiency.

This paper adds additional empirical weight to the results of earlier studies of competition in school markets. As stated earlier, market-based reforms have mixed effects on the efficiency of public schools. In this study, the effect of competition from private schools is significant for Primary Schools and High Schools. Therefore, proponents of market based reforms should be aware that allowing more private schools, or even voucher programs, will increase students' performance in public schools. Thus, to increase overall public school education quality market-based reforms may be an ideal solution.

The sample does not include information on private school student test scores due to the unavailability of private school data. We cannot observe the efficiency of private schools. However, such data would not be useful because the goal of this paper is to examine the effects of competition from private schools on public school performance. An obvious limitation of this study is that it only focuses on one state. Currently, it is impossible to conduct a similar analysis at the national level. This is because a GIS-enabled data set of school locations does not exist at the national level currently. A GIS database including the geographic location for every school building in the state of Mississippi is constructed for use in this paper. The time costs of doing this for all fifty states are well beyond the scope of resources and time available for this paper. But it will be helpful for future researchers to construct and maintain such a database. However, the value of the GIS approach is great, and this paper may be considered as a case study to the potential of using GIS tools to address educational reform issues. The potential benefits of GIS analysis for educational policy research are vast, and this study should provide an example for future researchers to build upon and follow.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.econedurev.2012.08.001.

References

Adkins, L. C., & Moomaw, R. L. (2007). Analyzing the technical effieicny of Oklahoma schools. *Journal of Economics*, *23*, 41–61.

Aigner, D. J., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function model. *Journal of Econometrics*, *6*, 21–37.

Alspaugh, J. W. (1992). Socioeconomic measures and achievement: Urban vs rural. *Rural Educator*, *13*, 2–7.

Alspaugh, J. W., & Harting, R. D. (1995). Transition effects of school grade-level organization on student achievement. *Journal of Research and Development in Education*, *28*, 145–149.

Arum, R. (1996). Do private schools force public schools to compete? *American Sociological Review*, *61*, 29–46.

Belfield, C. R., & Levin, H. M. (2002). The effcets of competition between schools on educational outcomes: A review for the United States. *Review of Educational Research*, *72*, 279–341.

Blackmore, J. (1989). Educational leadership: A feminist critique and reconstruction. In J. Smyth (Ed.), *Critical perspectives on educational leadership* (pp. 93–129). Barcombe: Falmer Press.

Blair, J. P., & Staley, S. (1995). Quality competition and public schools: Further evidence. *Economics of Education Review*, *14*(2), 193–198.

Borland, M. V., & Howsen, R. M. (1993). Students' academic achievement and the degree of market concentration in education. *Economics of Education Review*, *11*, 31–39.

Braddcock, J. H., & Eitle, T. M. (2004). The effect of school desegregation. In *Handbook of research on multicultural education* (2nd ed.). New York, NY: John Wiley and Sons Press., pp. 828–846

Birks, S. (2003). *Economics and Policy - Worlds Apart?* Palmerston North, New Zealand: Centre For Public Policy Evaluation.

Ching, G. H. (2000). *The technical efficiency of education production: An analysis of Mississippi school districts* (pp. 1–122). Dissertation. Mississippi, USA: UMI.

Cho, J. I. (2009). *An efficiency and productivity study in the presence of the No Child Left Behind Act in Pennsylvania school districts* (pp. 1–195). Dissertation. Pennsylvania, USA: UMI.

Coe, P., Howley, C. B., & Hughes, M. (1989a). *The condition of rural education in Kentucky. A profile*. ERIC Document Reproduction Service No. ED 319579. Charleston, WV: Appalachia Educational Laboratory.

Coe, P., Howley, C. B., & Hughes, M. (1989b). *The condition of rural education in Virginia: A profile*. ERIC Document Reproduction Service No. ED 319577. Charleston, WV: Appalachia Educational Laboratory.

Couch, J. F., Shughart, W. F., & Williams, A. (1993). Private school enrollment and public school performance. *Public Choice*, *76*, 301–312.

Dee, T. S. (1998). Competition and the quality of public schools. *Economics of Education Review*, *17*, 419–427.

Epple, D., & Romano, R. (1998). Competition between private and public schools, vouchers and peer-group effects. *American Economic Review*, *88*, 33–62.

Fairlie, R. W. (2006). *Racial segregation and the private/public school choice*. Research Publication Series. National Center for the Study of Privatization in Education. http://www.ncspe.org/publications_files/OP124.pdf

Geller, C. R., Sjoquist, D. L., & Walker, M. B. (2006). The effect of private school competition on public school performance in Georgia. *Public Finance Review*, *34*, 4–32.

Glenn, H., & Anthony, P. O. (2010). Market structure and firm strategy. In *Microeconomics* (2nd ed.). New Jersey: Prentice Hall/Pearson., pp. 370–396

Greene, K. V., & Kang, B. G. (2004). The effect of public and private competition of high school outputs in New York State. *Economics of Education Review*, *23*, 497–506.

Haller, E. J., Monk, D. H., & Tien, L. T. (1993). Small schools and higher-order thinking skills. *Journal of Research in Rural Education*, *9*, 66–73.

Hanushek, E. (2006). *Performance incentives for teachers and administrators*. Retrieved from http://www.senate.state.tx.us/75r/Senate/Commit/c525/handouts06/02272006.c525.hanushek.pdf

Hanushek, E. A. (1998). Conclusions and controversies about the effectiveness of schools. *Economic Policy Review*, *4*, 11–17.

Hanushek, E. A. (1999). Some findings from an independent investigation of the Tennessee STAR experiment and from other investigations of class size effects. *Educational Evaluation and Policy Analysis*, *21*, 143–163.

Hanushek, E.A. & Rivkin, S.G. (2003) *Does public school competition affect teacher quality? In Economics of School Choice*, edited by Caroline M. Hoxby, pp. 23–47. Chicago: University of Chicago Press (for NBER).

Hanushek, E. A., & Woessmann, L. (2009). *Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation*. Working

Paper No. 14633. Massachusetts Avenue, MA, USA: National Bureau of Economic Research. http://www.nber.org/papers/w14633

Haslett, B. J., Geis, F. L., & Carter, M. R. (1992). *The organizational woman: Power and paradox*. Norwood, NJ: Ablex Publishing Corporation.

Heish, C., & Urquiola, M. (2003). *When schools compete, how do they compete? An assessment of Chile's nationwide school voucher program*. Working Paper No. 10008. Cambridge: National Bureau of Economic Research.

Hoxby, C. M. (1994). *Do private schools provide competition for public schools?* NBER Working Paper Series. Cambridge, MA: National Bureau of Economic Research.

Hoxby, C. M. (2002). *School choice and school productivity, or could school choice be a tide that lifts all boats*. NBER Working Paper No. 8873, Cambridge, MA. Available from http://post.econonmics.harvard.edu/faculty/hoxby/papers.html

Jepsen, C. (2002). The role of aggregation in estimating the effects of private school competition on student achievement. *Journal of Urban Economics*, *52*, 477–500.

Johnson, S., Busch, S., & Slate, R. J. (2008). *Leadership behaviors of school administrators: Do men and women differ?* Retrieved from http://cnx.org/content/m18693/1.1/

Kantabutra, S. (2009). Using a DEA management tool through a nonparametric approach. *International Journal of Education Policy and Leadership*, *4*, 1–14.

Kantabutra, S., & Tang, J. (2006). Urban–rural and size effects on school efficiency: The case of Northern Thailand. *Leadership and Policy in Schools*, *5*, 355–377.

Kleinfeld, J. S., McDiarmid, G. W., & Hagstrom, D. (1985). *Alaska's small schools: Are they working?* Institute of Social Science and Economic Research, Center for Cross-Cultural Studies, University of Alaska. Retrieved from http://www.alaskool.org/native_ed/research_reports/small_rural_hs/rhsklein.html

Kumbhakar, S. C., & Lovell, C. K. (2000). *Stochastic frontier analysis* (1st ed.). Cambridge, UK: Cambridge University Press.

Marlow, M. L. (1997). Public education supply and student performance. *Applied Economics*, *29*, 617–626.

Marlow, M. L. (2000). Spending, school structure, and public education quality. Evidence from California. *Economics of Education Review*, *19*, 89–106.

McMillan, R. (2000). Competition, parental involvement, and public school performance. In *Proceedings from the annual meeting of the National Tax Association* (pp. 150–155). Washington, DC: National Tax Association.

Meeusen, W., & Van Den Broeck, J. (1977). Efficiency estimation from Cobb–Douglas production functions with composed error. *International Economic Review*, *18*, 435–444.

Melvin, P. D., & Sharma, S. C. (2007). *Efficiency analysis of K-12 public education in Illinois*. Retrieved from http://www.economics.siuc.edu/facultyandstaff/pdfs/DP2007EfficiencyAnalysis.pdf

Misra, K., & Chi, G. (2011). Measuring public school competition from private schools: A gravity-based index. *Journal of Geographic Information System*, *3*(4), 306–311.

Newmark, C. M. (1995). Another look at whether private schools influence public school quality: Comment. *Public Choice*, *82*, 365–373.

Reeves, E. B., & Bylund, R. A. (2005). Are rural schools inferior to urban schools? A multilevel analysis of school accountability trends in Kentucky. *Rural Sociology*, *70*, 360–386.

Rhoades, S. A. (1993). *The Herfindhal–Hirschman Index*. Retrieved from The Board's Division of Research and Statistics.

Sander, W. (1999). Private schools and public school achievement. *Journal of Human Resources*, *34*, 697–709.

Schofield, J. W. (1995). *Review of research on school desegregation's impact on elementary and secondary school students*. New York, NY: MacMillan Press.

Schofield, J. W., & Hausmann, L. R. M. (2004). School desegregation and social science research. *American Psychologist*, *59*, 538–546.

Simar, L., & Wilson, W. P. (2007). Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics*, *136*, 31–64.

Simon, C. A., & Lovrich, N. P. (1996). Private school enrollment and public school performance: Assessing the effects of competition upon public school student achievement in Washington State. *Policy Studies Journal*, *24*, 666–675.

Snyder, J. H., & West, R. F. (1992). The effects of retention in elementary school on subsequent academic performance. In *Annual meeting of the Mid-South Education Research Association*. ERIC Document Reproduction Service No. 356-045.