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AUTHOR	Belfield, Clive R.; Levin, Henry M.
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ABSTRACT

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The Effects of Competition on Educational Outcomes: A Review of US Evidence

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Clive R Belfield

cb2001@columbia.edu

Henry M Levin

hl361@columbia.edu

National Center for the Study of Privatization in Education

Box 181, Teachers College, Columbia University,

W.120th Street, New York NY 10027-6696

www.ncspe.org

Abstract This paper systematically reviews the cross-sectional research evidence on the effects of competition on educational outcomes. Competition is typically measured using either the Herfindahl Index or the enrollment rate at an alternative choice (e.g. private school). Outcomes are separated into those relating to academic test scores, graduation/attainment, expenditures/efficiency, teacher quality, wages, and house prices. The sampling strategy identifies over 35 empirical studies testing the effects of competition. A sizable majority of these studies report beneficial effects of competition across all outcomes, with many reporting statistically significant coefficients. The effect size of an increase of competition by one standard deviation is also reported. These effect sizes suggest positive gains from competition that are modest in scope with respect to feasible changes in levels of competition. Finally, this review notes some methodological challenges in estimating competitive pressures, as well as cautions on the validity of inference from point estimates to public policy.

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1. Introduction

Widespread concern with the quality of public education, particularly among schools attended by minority and low-income students, has generated calls for educational reform. Some reformers have pushed for higher standards for student promotion and graduation with the use of high-stakes tests by which students and schools will be judged. Others have sought market-type reforms to generate more private and public options for students and to create incentives for schools to compete for students. These reforms include educational vouchers and tuition tax credits to promote private alternatives and charter schools, magnet schools, and decentralization of larger school districts to create competition for students within the public sector.

This recent focus on the impact of competition on educational production has generated a substantial empirical literature. This paper reviews systematically the research evidence on the effects of competition on educational outcomes. Many economists (including the present authors) believe that market competition improves both technical and allocative efficiency in the use of resources. Indeed, a substantial corpus of evidence – both across macro-economic systems and at the micro-level of particular industries or locales – can be adduced to support this belief. However, what is less clear is the generality and scale of these efficiency gains in education. How much and according to what measures of output does increased competition improve educational quality? This paper offers answers to these questions, based on a detailed review and evaluation of the extant cross-sectional evidence.

The paper is structured as follows. Section 2 describes the strategy for selecting studies and considers the validity of 'competition' as a construct. Section 3 reports the evidence on the effects of competition on academic achievement outcomes such as test scores. Section 4 reports on the effects of competition on other measures of schooling

quality such as graduation rates, efficiency, and teacher pay. In Sections 3 and 4 the methodological challenges and sensitivity of the results are also considered. Additional data to support these two sections are given in Appendix Tables. Section 5 summarizes the results, assesses the substantive significance of this evidence, and draws some inferences for education policy. Section 6 provides a summary. A large amount of detail is included in four Appendix Tables.

2. Identifying the Evidence on Competition

2.1 The Sampling Frame for Review

The sample for review was selected using the following protocol. The Web of Science database was searched from 2001 back to 1972, using 'competition', 'markets' and 'education' as keywords. The relevant papers were then checked for further citations (and two journals were hand-searched: *The Economics of Education Review* and *Public Choice*). The sample analysed here is on research on schooling (not higher education), and for the US. Only research with an explicit measure of market competition is included. Essentially, the review focuses on the link between educational outcomes and competitive pressures across large markets.[1] This focus is motivated by three reasons: (a) there is a recent review by McEwan (2001) of public versus private school effectiveness which speaks to the school choice debate; (b) large-scale, cross-sectional evidence is useful because there is some

[1] The two main outcomes that are omitted from this review are changes in parental involvement and measures of satisfaction with schooling. For libertarians, competition is equated with choice, and choice is an end in itself. Thus, parental involvement and satisfaction with schools are likely to be two useful outcome measures, proxying for the ability to choose.

concern over the external validity of small-scale voucher programs (Goldhaber, 2001); and (c) the literature reviewed here is often collectively referenced in policy debates (Hoxby, 1999b).[2] Finally, studies were rejected from the sample where no dataset was referred to.[3]

For exposition, the evidence is divided across several domains. In Section 3, the effects of competition on academic outcomes – typically standardized test scores – are reported; it is this domain for which most evidence is available, and where more proxies for competition are utilized. Section 4 reports the effects across a range of other educational outcomes including educational attainment, expenditures, efficiency, teacher salaries and conditions, private school enrollments, housing prices, and wages.

[2] For research on small-scale voucher programs such as those in Milwaukee and Florida, see Rouse (1998) and Witte (1999). For evaluations of competition-driven reforms (e.g. studies of decentralization, the introduction of charter schools), see Hoxby (1998). For tests of the efficiency of general public goods provision, see Hayes et al. (1998). For simulations of market reforms, see Manski (1992), Epple and Romano (1998), Rangazas, (1995), and Grosskopf et al. (1999a).

[3] This rejection criterion serves to exclude only one contribution. Specifically, Hoxby (1999b) reports a sizable set of results from market forces. Competition between public school districts: (1) reduces per pupil spending, by 17%; (2) improves student test scores, by 3 percentile points; (3) improves wage outcomes for students, by 4%; (4) raises attainment, by 0.4 years of education; and (5) raises parental involvement, with 30% more school visits. Competition between state schools and private schools: (a) has no effect on per pupil spending; (b) raises state school spending, by 8 percentile points; (c) raises wages for state school students, by 12%; and (d) increases the probability of college graduation by state school students, by 12%. However, the data source for these findings is reported as 'on author' and may be the same as those estimations attributed to Hoxby in our main text.

2.2 *Construct Validity and Identification Strategy*

Before reviewing the evidence, two concerns are raised here. The first is that of construct validity – the meaning of 'markets' and 'competition' – and the second is that of estimation – accurately identifying the effects of competition. Two other concerns, of sensitivity and of publication bias, are addressed directly in the discussions below.

First, inference from the evidence depends on the 'education market' and 'competition' being valid constructs (see Taylor, 2000). Specifically, an education market exists where parents have a feasible choice set of alternative provision. Ostensibly similar provisions may not always be legitimate components of the choice set: religious and non-religious schools may not be straight substitutes within a choice set, for example. For low-income families, private and public schools may not represent a 'single market': parents choosing a private school incur tuition fees; parents choosing a different public school may incur residential re-location costs, and or costs of appealing to the school district for re-assignment (Couch and Shughart, 1995). As well, choices can be made either at the state level, district level (Tiebout choice), or school level (or even within a school). Yet, levels of choice at each level may be simultaneously determined (with weak choice at one level offset by strong choice at another level).

Similarly, competition as a construct refers both to the existence of more education suppliers within the choice set, and to how these suppliers behave strategically. Competitive pressures from a neighboring public school may differ from those of a neighboring private school; competition may be horizontal (between services) or vertical (for inputs); or competition may impact only at a critical threshold level.

Typically, competition is assessed using the Herfindahl Index (HI), the sum of the squares of per-unit enrollments over total enrollments (Borland and Howson, 1992). In this

literature, the Index typically relates to public school choices, either inter- or intra-district. Bounded between 0 (full competition) and 1 (monopoly), the Index may be regarded as continuous or may be used to identify a critical competition threshold.[4] Another measure of competition is the private schooling enrollment share. This share may represent competition, but may also be determined by other factors, such as regional religiosity, or community wealth levels.. However, neither measure of competition captures how or whether schools or districts compete: some schools may be 'dominant firms'; others may collude; niche markets may develop; and schools may respond to competition either by changing their provision or by quitting the market (Hoxby, 1994). In some cases, the competition variable may equate to a distinction between urban and rural areas (Hoxby, 2001). Strictly speaking, in many cases the measure of competition is actually a measure of alternative or ostensible options (a 'choice set'), without a conception of actual strategic behavior.

Second, there are two estimation problems in correlating competition measures with educational outcomes (Dee, 1998). One is the problem of simultaneity. Competition refers to how suppliers behave, holding demand constant, yet available supply and effective private–public schooling demand are simultaneously determined. So, only the equilibrium quantity of supply and demand is observed. Hence, when public schooling is of low quality, the demand for private schooling will rise, creating a negative relationship between public school quality and private schooling enrollment.[5] The other problem is that of omitted

[4] One interpretation of the HI is that applied by the Federal Trade Commission. It defines (industrial) markets with HI values below 0.1 as unconcentrated; between 0.1 and 0.18 as moderately concentrated; and above 0.18 as concentrated (Barrow and Rouse, 2000). This definition may have limited pertinence to education markets: based on the results reported below almost all education markets are concentrated.

[5] An equivalent argument may be made for intra-public school choice – low quality districts may stimulate a taxpayer revolt to generate an alternative public school district, i.e. more choice. On changes in the numbers of school districts in the US since 1960, see Kenny and Schmidt (1994).

variable bias, i.e. when factors that confound the relationship between, say, public school quality and private school supply are omitted from analysis.[6] Ability-omission bias may arise where private schools cream-skim more able students; this will reduce average ability and educational outcomes in public schools. Resource-omission bias may arise where higher demand for private schooling reduces taxpayer support for public schooling. Socioeconomic-omission bias will arise if the demand for private schooling is influenced by local socio-economic characteristics (such as community income and education levels), but these also have a direct effect on educational attainment.[7] The evidence below sheds light on the importance of each of these problems.

Ideally, estimation techniques should identify the supply of alternative schooling and should control for key confounders. For studies using the Herfindahl Index to measure intra-district public school choice, identification of supply may be straightforward. For studies that use private schooling as the measure of competition with public schools, supply is identified through a source of variation – such as Catholic religiosity in the region – that is held to be uncorrelated with schooling quality. Typically, either two-stage (2SLS) or instrumental variable (IV) approaches are used (e.g. Zanzig, 1997; Borland and Howson, 1992). Evidence from this research survey helps to assess the impact of using these approaches over simple OLS correlations.

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[6] Relatedly, the precision of the point estimates on the competition measure may also be a function of the level at which competition is measured. As with the literature on resource effects, aggregation to district or regional level may inflate coefficients through omitted variable bias, raising the likelihood of Type I errors (Hanushek et al., 1996; although Taylor, 2000, finds the Leviathan hypothesis most strongly supported by local level analyses).

[7] Confounding is likely because private schooling will be more affordable to those in wealthier districts (and perhaps because wealthier districts may better lobby for competitive school systems). The income distribution may also influence the demand for private schooling and so the amount of competition: only families above an income threshold will be able to forgo free public schooling (Maranto et al., 2000). As well as the difficulty of controlling for differences in district circumstances, it is also important to establish whether the greatest variation in competition is within or between districts.

All evidence will be assessed in light of these concerns. In addition, both statistical significance and magnitude of findings will be scrutinized. The former will be established when a coefficient is accepted as different from zero at the 5% two-tailed level (or above). The magnitude of competitive impact or substantive significance will be established in terms of standard deviation changes to the educational outcome when the amount of competition increases by one standard deviation. These representations allow for comparative and uniform metrics to be applied across different studies and for consistent discussion of how much increases in competition would affect schooling quality. The evidence is summarized in the text below, and reported directly in four (lengthy) Appendix Tables. An overall summary Table is presented and discussed in Section 5. A glossary of terms is also reported as Appendix Table A5.

3. Competition and Academic Outcomes

3.1 Evidence for Academic Outcomes

Evidence from 23 studies on the effects of greater market competition on academic outcomes is given here (but see Appendix Table A1). A simple appraisal indicates that by far the majority (of the approximately 150 separate estimates) report a statistically significant correlation between increased competition and higher public school achievement. A trivial number show more competition impairs public school outcomes; but a sizable minority shows no effect. Here the studies are considered in more detail, divided by the measure of competition used.

Evidence Using the Herfindahl Index

The Herfindahl Index (HI) values in education markets range from 0.11 to 0.87, with an approximate average for the concentration level at 0.35 (and see Appendix Table A1). Broadly, these index values indicate education is highly concentrated compared to other sectors (Barrow and Rouse, 2000). Primary schooling is more competitive (or at least more atomistic) by this measure than secondary schooling.

Using the HI as a continuous variable, most empirical papers report only weak or null effects on academic outcomes. Borland and Howson (1992, 1995) found no statistically significant correlation between the HI and mean test scores across 170 districts in Kentucky. From a scatterplot, Hanushek and Rivkin (2001) discerned no correlation between HI values and school average test score gains across 27 metropolitan areas in Texas. Using regression, Marlow (2000) found mixed results for counties in California: 10 out of 18 estimations are not statistically significant at the 5% level; with the strongest effects at 8^{h} grade (but no effects for 10th grade). For the significant results, a one standard deviation decrease in the HI is associated with 4th grade Reading scores that are higher by about .22 standard deviations and writing scores by about .12 of a standard deviation. For eighth grade the figures are .41 for reading, .22 for writing, and .4 for mathematics.

Other studies use the HI to categorize education markets into high or low levels of competition. In general, this categorization yields more statistically significant results. For their data on Kentucky, Borland and Howson (1993) reported a statistically significant but substantively moderate effect above a critical threshold HI value: test scores are 3% higher when the HI value falls below 0.5. For California, Zanzig (1997) finds consistent effects of competition across two measures. First, where there are less than four local districts, a one standard deviation increase in their number (i.e. 0.64 extra districts) is linked to district 12th grade test scores that are about 0.1 standard deviations higher. Second, where the HI is over

in private school enrollments is associated with an increase in public school test scores by 0.22 standard deviations. Newmark (1995) replicated this result, and found similar effects. But he also showed that these effects were not robust: from 12 other specifications, none showed a statistically significant relation of private school enrollment and public school test scores. In a similar estimation, Geller et al. (2001) found no significant effects on academic outcomes employing differenced and lagged values of competition (using either the number of private schools or the percent of private enrollments); and Simon and Lovrich (1996) found broadly neutral effects using data on districts in Washington state. Using school-level data, Sander (1999) found no significant effect on Math scores within the State of Illinois.

Smith and Meier (1995) found the percentage of public school students passing standardized tests (in the subjects of mathematics and of communications studies) was lower with higher private school enrollment across Florida districts. These effects appear substantively small: for tests in communications, an increase of four percentage points in private school enrollment is associated with a decrease in 1 percentage point in public school performance in the following year. Moreover, these results are sensitive to the income distribution. In a re-estimation of Smith and Meier's (1995) Florida data, Maranto et al. (2000) split the sample across high- and low-income families. For low-income districts, competition reduces public school test scores (generally, a statistically significant result, as well as substantively important); for high-income districts, competition has ambiguous effects.[9]

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[9] In a further adjustment of Smith and Meier's (1995) specification on lagged test scores, Maranto et al. (2000) adjust for inflation in measuring mean district family income. Although the pooled sample shows a negative coefficient, the effect is no longer statistically significant. For the low-income sample, there is a statistically significant negative effect; but there is no effect for the high-income sample. Maranto et al. (2000) run further regressions with additional lags and find more null results. For the negative effects for low-income families, however, the effects appear substantively large: approximately, increasing private

0.58, a one standard deviation fall in the HI is associated with district 12th grade test scores that are lower by about .10 standard deviations. However, using individual-level data from NELS, Figlio and Stone (1999) found no clear positive effects: the test score gap between public and private (religious or non-religious) schools is unaffected by stratification according to whether the schools are in high or low competition areas.

Finally, the HI can be interacted with other process measures. Hanushek and Rivkin (2001) interacted their HI scores with the percentage of different teachers across 1140 schools and 832 districts in Texas. For this estimation, more competition leads to a smaller between cohort variance in school average value-added test scores; the latter proxies for teacher quality variance (more competition should reduce the school/district variance in teaching quality, because poor teachers would not be hired, monitoring of teachers would be better etc.). At the school level, a one standard deviation increase in competition reduces this cohort variance by roughly 0.09 standard deviations. However, these results are not robust to sample decomposition.[8]

Evidence Using Private School Enrollment

Higher private school enrollments may also serve as a measure of competition for public schools. Several studies have used this measure, and these are included in the middle component of Appendix Table A1.

Across districts and counties, the effect of private school competition on public school outcomes is mixed. Couch et al. (1993) correlated county private school enrollments with 8th–12th grade Algebra test scores for North Carolina: a one standard deviation increase

[8] Mixed results are obtained from sub-samples: no effect of competition is found for schools with less than 25% of students eligible for Free School Lunch, but a beneficial effect is found where at least 75% of students are eligible. No competitive effects are found at the district-level, however (Hanushek and Rivkin, 2001).

Several studies use individual, student-level data to test for the effects of private school enrollments on academic outcomes. Using the NELS data, McMillan (1998) found weakly negative effects on public school 8th grade scores (although in the strongest case, a one standard deviation increase in private school enrollment was associated with lower scores for individual public school student by 0.66 standard deviations). Using High School and Beyond data, Arum (1996) found a positive effect for individuals' 12th grade test scores. Here, the effects were substantively small: a one standard deviation increase in private schooling was associated with a 0.01–.02 standard deviation increase in test scores. From the NLSY (1979–90) and using an Instrumental Variables technique, Hoxby (1994) found that AFQT scores were positively associated with competition, but the magnitude is small with only a one percentile gain for a standard deviation increase in the Catholic enrollment share. Finally, using NELS and NLS72 with 2SLS estimation, Jepsen (1999) regressed standardized mathermatics scores against four measures of private school competition. Only one was statistically significant (NLS72, county level competition), and this effect was substantively weak (with OLS estimation yielding no statistically significant results).

Evidence Using Other Measures of Competition

The third set of evidence on academic outcomes uses proxy measures for competition. The proxy measures are idiosyncratic, but have some affinity to Herfindahl Index values. This evidence is reported in the bottom component of Appendix Table A1.

Using the number of districts/schools per 1000 students, Marlow (1997) found a strongly positive statistical effect on Math SAT and 8th grade scores, and (more weakly) Verbal SAT scores across the 50 states. The substantive influence of these variables does

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school enrollment by one standard deviation reduces the percentage of public school students who pass exams by one standard deviation.

not appear to be large, however. Using the number of neighboring districts, Blair and Staley (1995) found no effect on district-level achievement test scores in Ohio. However, using the average district test scores of adjacent districts as a proxy for competition there is a positive effect on test scores. Where average adjacent-district test scores are one standard deviation higher, home-district test scores are 0.41 standard deviations higher. In contrast, using the numbers of neighboring public school districts, Geller et al. (2001) identified no positive effects on academic scores in Georgia (and in one estimation – 10^{th} grade reading – the correlation is negative).

Finally, Hoxby (2001) used as a measure of school choice the share of a district's enrollment in a particular metropolitan area, with an instrumental variable based on the natural boundaries to the formation of school districts. This index (range 0-0.97, standard deviation of 0.27) is higher where there is greater choice. Hoxby (2001) reported the effects of going from minimum to maximum amounts of inter-district choice: but, in terms here of one standard deviation changes, 8^{th} grade reading scores are 1.03 percentile points higher, 10^{th} grade math scores are 0.84 percentile points higher, and 12^{th} grade reading scores are 1.56 percentile points higher. When the percentage in private school enrollment is used as a measure of competition, academic scores increase by 2.5–3.7 percentile points when private school choice goes from moderately 'low' to moderately 'high'.

3.2 Sensitivity Analysis and Publication Bias

These results (see Appendix Table A1) are generally consistent in suggesting modest gains in achievement from competition. There were few negative correlations, although a large number that were statistically insignificant. However, a general concern regarding mis-measurement still remains. For the dependent variables, the (artificial score) variables may

have non-normal distributions, be compressed or bounded, or be sensitive to outlier results. Many estimations do not explicitly use the student 'yield', i.e. the proportions of students taking the test within a given jurisdiction (see Newmark, 1995). Yet, states where educational quality is low may submit fewer students to standardized testing (and in the case of the SAT, students self-select themselves for the test. For the independent variables, the distribution of the Herfindahl Index may be sensitive to outliers; and variations in the numbers of private school students are often small or static over time.[10]

In checking for robustness of the results, a number of papers do report sensitivity tests. One important set of tests relates to the estimation method, i.e. whether the study compensates for simultaneous determination of the dependent and independent variable. Instrumental variables should be used to address simultaneity, but the value of such estimation depends on the quality of the instruments that are available. Based on comparing results using different estimators, however, instrumental variable estimation may not be necessary for generating reasonably precise point estimates. Five contributions explicitly identify no empirical advantage from using 2SLS over ordinary least squares. In contrast, two find an advantage from using 2SLS. When private school supply is used as the measure of competition, 2SLS estimation raises point estimates of the effects.[11]

Another set of sensitivity tests relates to the derivation of the key variables and to omitted variable bias. For example, Newmark (1995) estimates a basic model and then separate models: for seven additional academic subjects; without population density; with

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[10] In addition, in a non-trivial proportion of the empirical studies the mean and spread of the dependent and key independent variables are not reported. It is therefore not possible to make direct inference on the marginal effects of competition.

[11] The five contributions that explicitly identify no empirical advantage from using 2SLS over ordinary least squares are: Smith and Meier (1995); Couch et al. (1993); Schmidt (1992); Sander (1999); and – generally – Jepsen (1999). The two that find 2SLS raises point estimates are Dee (1998) and Hoxby (2000a, 2001). See also the specification tests in Borland and Howson (2000).

private enrollment Census measures (which include home-schooling and exclude kindergarten); with only non-religious private school enrollment; and with adjustments for student yield. In none of these cases are the simple results from Newmark (1995) and Couch et al. (1993) replicated. Across Appendix Table A1 (and subsequent tables), many studies report both significant and insignificant correlations, often for equally plausible specifications. This spread of results suggests that the effects of competition are sensitive to the specification utilized. This raises the possibility of bias whereby a specification is chosen because it shows statistically significant results (see Begg, 1994). Moreover, studies may only be published where they show statistically significant results (Shadish and Haddock, 1994). Publication bias is of particular concern in areas of inquiry where there are a large number of small-sample studies; where fewer randomized trials are conducted; and where research is ideologically motivated. Overall, there may be a tendency for bias toward discovering a link between competition and outcomes.[12]

4. Competition and Educational Quality

4.1 Evidence for Educational Quality

In addition to academic outcomes, many studies consider the effects of greater competition on other measures of educational quality and performance (see Appendix

[12] A full meta-analysis with sensitivity testing is beyond the scope of this paper. However, publication may be gauged from a scatterplot of standard errors against respective point estimates. As the effect of competition should not vary with the size of the standard error, this plot should have a line of best that is horizontal: if there is a tendency to report only when the t-ratio is greater than 1.96, as the standard error increases, so must the coefficient to preserve the ratio greater than 1.96 (see Ashenfelter et al., 1999). Based on 102 point estimates from Table 1, the line of best fit was upward sloping ($\hat{a} > 0$, at the 5%

Tables A2, A3 and A4). The studies use a range of proxies for competition, and are listed here according to the measure of educational quality used as the dependent variable.

4.2 Educational Attainment

Appendix Table A2 reports the apparent effects of competition on drop-out rates, graduation rates, and college attendance.

For drop-out rates, Marlow (1997) found that states with more districts or more schools (per student body size) had lower drop-out rates (although no substantive effect can be determined). For graduation rates, Dee (1998) found private school student numbers raise graduation rates across a sample of almost 4,500 school districts. The elasticity of graduation with respect to private school competition is small, however, at 0.03; a one standard deviation increase in private schooling raises public school graduation rates by 0.18 standard deviations (1.7 percentage points). In directly addressing simultaneity, Dee (1998) compared OLS estimation with 2SLS estimation (where Catholic population levels are used to identify supply): OLS estimation appears to understate the positive effects of private school competition. However, using the same model and instrument, Sander (1999) found no statistically significant effect either on graduation rates, or on proportions of college-bound students in Illinois.

For attainment, graduation, and college attendance, Jepsen (1999) used individual level data from NLS72 and NELS and found broadly neutral effects of competition. For attainment, the NLS72 shows no effect of greater competition on years of schooling; and the NELS shows at best weakly positive results on high school graduation (a one standard

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significance level); this suggests the possible existence of publication bias and so over-statement of the benefits of competition (but is not conclusive because of the different specifications used in the studies).

deviation increase in competition across zip codes actually reduces graduation rates by 0.11 standard deviations). For college attendance, similarly weak results are found (with three of four estimations not statistically significant): a one standard-deviation increase in private school share at the county level raises the probability of going to college by at most 0.14 standard deviations. Generally, these results are invariant to OLS or 2SLS estimation.

For attainment, graduation with a diploma, and college graduation, Hoxby (1994) used the percentage of Catholic/private schools to identify competition, with NLSY data. On attainment, the instrumental variables approach yields a statistically significant positive correlation: an increase of one standard deviation in Catholic or private schooling raises years of education by 0.08 standard deviations. (Alternatively expressed, a 10 percentage point increase in the share of enrollment in Catholic [private] schools produces an extra 0.33 [0.35] years of education for public school students). On graduation with a diploma, and on college graduation, positive (and robust) effects of competition are also identified: a one standard deviation increase in the Catholic enrollment share increases these variables by 1–1.5 percentage points. (These results are only found with instrumental variables, however; FGLS estimation does not yield statistically significant results).

4.3 Educational Expenditures

Appendix Table A3 reports on the relationship between competition and resource levels. Competition may have conflicting influences here: more efficient enterprises operating in a competitive market may be rewarded with higher subventions (because they generate more human capital for a given quantum), or may be allocated lower funding (to

generate the standard amount of public school human capital).[13] As shown in Appendix Table A3, the evidence on the link between educational expenditures and competition is mixed.

Using state-level Census data, Kenny and Schmidt (1994) found the least competitive quartile of states (i.e. those with the fewest school districts) had higher state-level expenditures, by 12% ($336 per student in 2000 dollars). Perhaps this indicates diseconomies of scale from having large districts. With large city 1970 Census data, Lovell (1978) reported no effect on public school expenditures from the proportions of private schools. Also using state-level data, Marlow (1997) reported mixed effects on spending by competition levels: where the number of schools per 1,000 students is higher, so is funding; but the number of districts has no statistically significant effect. For California, though, Marlow (2000) reported more conclusively on lower spending where the HI value is lower. At the county level, a decrease in the HI of one standard deviation reduces per-pupil spending by .53–.59 standard deviations. However, using 1980 Census data, Arum (1996) found the percentage of private school enrollment has a positive effect on public school expenditure: increasing private school attendance by one standard deviation raises public school expenditures by .22–.26 standard deviations. This translates into increases of $209 (in 2000 dollars) per student for each four percentage point increase in private school enrollment. With panel data for New York state, Goldhaber (1999) reported greater private school enrollment raises public school expenditures (this is for two of four specifications; the other two are not significant). For New York state, the effect appears very large:

[13] In looking at Tiebout choice, Hoxby (2000) describes how educational spending may be affected by the demographic mix. Where there is little Tiebout choice for families, then asset-rich and asset-poor families will be mixed into the same district. This will reduce the demand for education by the asset-rich, as they bear a larger burden of public financing of their district's education. But it will raise the demand by the

increasing private school enrollments by four percentage points raises public school expenditure by 2.73–1.93 standard deviations, or $3304–$2334 (2000 dollars). With MSA census data, Schmidt (1992) found higher a (predicted) proportion of students in private schools raises per pupil expenditures, although the relationship appears substantively trivial. Also using Census data, Burnell (1991) found that less centralized (i.e. more competitive) school districts in a given county had higher expenditures per pupil.

Hoxby (2000a) used a range of measures of competition to test for changes in spending, and found the results sensitive to the estimation method. With data on 211 metropolitan areas, Hoxby (2000a) found a one standard deviation increase in inter-district choice (based on enrollment options across districts) reduced spending by 2.1%. However, competition from private school enrollment only slightly increased spending per pupil in public schools by 0.1% (not reported in Appendix Table A3). Using the NLSY (1979–90), Hoxby (1994) found no statistically significant effects from competition on per-pupil spending, and only very weak negative effects for per-resident public school spending (of 0.07 standard deviations, or $73 in year 2000 dollars).

4.4 Educational Efficiency

Fundamentally, competition should be anticipated to raise efficiency levels in terms of output per unit of cost or cost per unit of output. Indeed, the evidence above is suggestive of greater efficiency: competition appears to raise performance, along with neutral or ambiguous effects on spending. In Appendix Table A3, the four studies that directly assess efficiency are reported.

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asset-poor. The net effect on spending will depend therefore on the political engagement of these two groups.

Grosskopf et al. (1999) found efficiency rises with competition among Texas school districts. Again, these competitive pressures – as measured by the HI – are not continuous. The threshold for 'low competition' is where the Index value equals 27.61 (with half the metropolitan areas and 20% of urban districts in concentrated markets). Below this value, concentration and inefficiency are not correlated; but in districts above the concentration threshold, predicted inefficiency is at least 40% higher.

Duncombe et al. (1997) reported mixed evidence on the link between cost-efficiency and competitive pressures across New York districts. Neither a greater number nor density of schools increases efficiency. In big City districts cost-efficiency is lower by 6.5%; yet, where the number of private school students in the district is greater, cost-efficiency is lower. Both these effects (*prima facie*, contradictory) appear statistically and substantively significant.

Finally, Hoxby (2000a, 2001) estimated productivity as the ratio of academic test scores and (log) per-pupil spending for metropolitan areas. Inter-district choice has a positive, statistically significant effect on productivity across each grade/subject. However, the effect appears to be substantively small. When inter-district choice rises by 0.25 (approximately one standard deviation), school productivity rises by approximately 2.5%, or 0.3 standard deviations.[14] Hoxby's (2000a) evidence on achievement and spending (reported in Appendix Tables A1 and A2) can be combined to interpret the efficiency gains from competition: increasing choice by 1 standard deviation (0.27 units), achievement is 0.8–1.5 percentile points higher, but spending is 1.9 percent lower. Together, these appear to be moderate gains. Similarly, competition from private schools also raises productivity, but the

[14] Hoxby (2000a, 28-29) describes the result thus: "if we compare two schools, the school in the metropolitan area with maximum choice has math scores that rise by more (0.308 percentile points more) for every 100 percent increase in per pupil spending than the school in the metropolitan area with minimum choice." As a summary, when inter-district choice goes from its minimum to its maximum value (from 0 to

effect appears to be very modest: if private schooling increases by 10 percentage points, a metropolitan public school has 8th grade reading scores that rise by only .27 percentile points more for every 100 percent increase in per pupil spending. As private schooling has broadly neutral effects on spending, productivity improvements from competition arise because of higher public school achievement when private school enrollments are higher (as reported in Appendix Table A1).[15]

4.5 Teacher Salaries and Teacher Quality

Greater competition may also influence how inputs are allocated and rewarded. Specifically, it may encourage districts to hire teachers of higher quality, and put pressure on teachers to deliver education that is more valuable to students (reducing teacher rents); this may raise either teacher numbers or teacher quality per dollar expended.[16] The research on teacher inputs is summarized in Appendix Table A4, with teacher quality measured in terms of teacher pay, conditions, and hours of instruction.

Several studies report on how teacher pay is influenced by competition. Using district-level data in Ohio, Vedder and Hall (2000), found average teacher salaries were higher either as within-state county private school enrollments rose, or as the number of

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1), school productivity rises by 10%; achievement is 3.1–5.8 percentile points higher; and spending is 7.6 percent lower.

[15] Arum (1996) reports on both student–teacher ratios and expenditure levels (see later in the main text). However, lower student–teacher ratios in states with high private sector enrollment are found to be a result of high expenditures, not greater teachers as a proportion of total staff. Using individual data from High School & Beyond, Arum (1996) finds that competition has a beneficial effect on public school performance primarily because it raises resource levels.

[16] Hanushek and Rivkin (2001) argue that a reduction in teacher variance would result from competition, because principals would be able to hire high quality teachers and fire low quality ones (and areas with low competition would also have lower monitoring). Yet, what teacher characteristics raise student performance are not well-identified. As represented in Table 1, Hanushek and Rivkin (2001) investigate teacher quality as reflected in the variance in student scores from year to year. Yet, Kane and Staiger (2001) attribute much of the variance in scores to year-on-year random variations, and to variations in sampling.

public school districts in a county increased. However, the effects are substantively small: a one standard deviation increase in private school enrollment would raise average public school salaries by approximately 1% ($380); and going from 1 to 12 public school districts in a county, raises salaries by 2% ($808). Borland and Howson (1993, 1995) found competition raises teacher salaries for districts in Kentucky; but, again, the effect is small, with salaries in low-competition districts reduced by approximately $700. Finally, Hoxby (1994) found a one standard deviation increase in the Catholic enrollment share increased public school teacher pay by 0.33 standard deviations ($794 in year 2000 dollars), a substantively significant effect.

Teacher conditions may also be influenced by the extent of competition. Marlow (2000) correlated Herfindahl Index values against the student–teacher ratio for California: a one standard deviation reduction in the HI raises student–teacher ratios by .45–.48 standard deviations (although this estimate is sensitive to model specification). Arum (1996) found the student–teacher ratio in public schools was correlated with private school enrollment across the states: for each increase of five percentage points in the private school sector (approximately one standard deviation), public schools had 1 less student per teacher (.47 of a standard deviation).[17] Also using national data, Hoxby (2000a) correlated inter-district choice and student–teacher ratios: instrumental variable estimations show a one standard deviation increase in choice (.27) reduces student–teacher ratios by .72 students (0.34 of a standard deviation). (But this result holds only for three of five IV estimations, and for none of the OLS estimations). Finally, Hoxby (2000b) found more choice leads to more working

[17] Looking at the gap between public and private school student–teacher ratios, Arum (1996) finds that the larger the private school sector in a state, the smaller the gap between public and private school student–teacher ratios. When the private school sector is at 10%, public school classes are 1.7 students larger. When the private school sector rises to 19%, public school classes are the same size as private school

hours for teachers: a one standard deviation increase in choice (0.27, from Hoxby, 2000a) raises instructional and non-instructional hours by .62 and .3 hours respectively, i.e. around 2–4%. The effects on other working conditions for teachers are mixed.[18]

4.6 Private School Enrollments

Competition is of course a two-way phenomenon: public schools themselves represent competition for private schools. Thus, the demand for private schooling is anticipated to be lower, when public schools compete against each other. Appendix Table A4 reports the studies of the determinants of private sector enrollments.

Smith and Meier (1995) found no relationship between lagged public school performance and private school enrollment for Florida. However, Goldhaber (1999) found that higher public school graduation rates (weakly) reduce enrollments in private schools in New York state. Martin-Vazquez and Seaman (1985) modeled primary/secondary private school enrollment against both district and school-level public competition; they found insignificant coefficients for each form of competition, but the negative sign on the interaction term is (weakly) supportive of higher district-choice reducing private schooling demand. Hoxby (2000a) regressed the share of students in private schooling on instrumented measures of district choice: four of the five estimations show greater district choice reduces private school student numbers (again, OLS estimation shows no significant

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classes. This evidence suggests some mimicking of technologies of provision across the public and private sectors.

[18] A measure of competition based on private school choice within an area does not produce any statistically significant effects. Plus, Hoxby (2000b) finds no statistically significant correlation between the amount of control and influence that teachers have and either school choice or the share of private school attendance within the metropolitan area. (For other measures of teacher quality, Hoxby, 2000b, does find statistically significant results from greater competition).

effects). Where district choice increases by one standard deviation, the share of students in private schools falls by .18 standard deviations (1.1 percentage points).

4.7 Housing Prices

Given local education funding, house prices serve as a way to capitalize the quality of public schooling. By extension, if competition raises educational quality, it should also raise house prices. One study that reports on this relationship is summarized in Appendix Table A4 (but see also the estimations of related models, e.g. Brasington, 2000). Using Census data, Barrow and Rouse (2000) model the relationship between state aid for education and house prices, with the sample divided into high, average and low Herfindahl competition. Whereas increases in state aid appear to negatively affect house prices in districts with average and low competition, they positively affect house prices in districts where competition is strong. Hence, more competitive districts may be more efficient, insofar as this is capitalized into house prices.

4.8 Wages

Earnings of educated adults may be a useful indicator of education quality (or the extent to which education generates human capital). Using individual-level data from the NLS72, Jepsen (1999) regressed (with 2SLS) log wages against four different measures of private school competition. Only one measure – county-level competition – generates statistically significant effects, with a one standard deviation increase in private school enrollments raising hourly wages by .09 standard deviations, or around 4% (no statistically significant effects emerge using OLS). Using NLSY (1979-90), Hoxby (1994) also found a positive (but substantively small) effect on wages from increases in Catholic schooling

enrollment: a one standard deviation increase in this competition raises wages at age 24 by 1%.

4.9 Sensitivity Analysis

The effects of competition appear to be consistently positive across these diverse education measures. Given the different outcome variables and the range of estimation techniques, this consistency suggests the results are reasonably valid. Nevertheless, tests of sensitivity are appropriate to check for a systematic bias in the evidence. However, it is not possible to test for publication bias (as in Section 3.2). Plotting effect sizes is not meaningful with small samples (a test proposed by Shadish and Haddock, 1994), and the outcome measures cannot be pooled. Instead, the sensitivity analyses within each study are discussed.

Overall, the sensitivity tests suggest that these results are not typically robust to alternative specifications. There are only a few studies where a correlation showing the beneficial impact of competition cannot be undermined, either by an alternative estimation technique or model specification. For example, Kenny and Schmidt (1994) reported on the sensitivity of their estimation of lower competition on per pupil expenditure. The relationship is statistically significant with the predicted value of 'less competition.' However, no statistically significant relationship emerges either with 'less competition' re-derived in two equally plausible ways, or with the actual value of district competition. Martin-Vazquez and Seaman (1985) found no threshold effect for competition; and their sensitivity tests reported weaker results (for example, normalizing the square mileage of the metropolitan areas generates statistical insignificance in all cases). Vedder and Hall (2000) reported five sensitivity tests: adjusting for ability; adding in dummy variables to control for large cities; excluding school districts with greater than 10000 students; including only

disadvantaged students; and including only high socio-economic status districts. The coefficients on both private school enrollment and competition remain statistically significant, but now vary widely (by factors of 2 and 6 respectively). The lack of robustness reported in these studies is the norm, rather than the exception, across the literature; this sensitivity is reflected in the final column of each Appendix Table, where statistical significance is reported.

5. Policy Reform and Competition

5.1 Competition Policy

The individual results reported in the Appendix Tables suggest (rather than conclusively establish) a potentially important policy: increasing competition – either intra-district, inter-district, or from private schools – may raise effectiveness and efficiency, as well as other educational optimands. Although statistically significant, however, the aggregate effects of competition in fact need to be substantively significant. Moreover, to represent a practical, desirable policy reform, these substantive benefits must be set against any increases in costs that are required to boost competition in education.

5.2 The Substantive Benefits of Increased Competition

The substantive significance of competition is summarized in Table 1, across each of the outcome variables (except housing prices). On a simple vote count, not adjusting for sample size, between 36% and 67% of estimations are statistically significant and positive; a trivial number of less than 3% show competition worsens outcomes. There are benefits from higher competition, but the substantive effects – across the set of outcomes – appear to be modest, based on an increase in competition of one standard deviation.

Educational outcomes are higher in more competitive markets (although column 3 of Table 1 shows that more than half of all reported estimations were not statistically significant). Using the Herfindahl Index against educational outcomes, a one standard deviation increase in competition would probably increase test scores by approximately .1

standard deviations or about four percentiles.[19] Using either private school enrollments or other proxies as measures of competition, the effect size is probably less than .1, with many fewer results being statistically significant. Somewhat more positive effects are found in studies where simultaneity and omitted variable bias are accounted for, but these too indicate small effects.

Some measures of attainment also appear to be enhanced by competition: using private school enrollments, graduation rates are higher by .08–.18 standard deviations. Spending appears to be ambiguously affected by competition: some evidence suggests more competitive school systems have lower spending, with other evidence indicating a .2–.4 standard deviation increase in spending. However, efficiency does appear to be positively correlated with competition: this inference is supported both directly by the evidence, and logically from the evidence on achievement and spending. Teacher quality is also affected by competition. Teacher salaries are higher with competition, by approximately .1–.3 standard deviations; but student–teacher ratios are probably lower with competition, up to 1 student lower. Together, these results may indicate reasonably high 'full benefits' to teachers from competition; but they also suggest that competition has significant effects on the technology of education (particularly if absolute spending is lower). Finally, student wages are raised by the extent of competition, to the order of approximately 1%.

Forms of Increased Competition

Moreover, effecting a one standard deviation increase in competition may require substantial (perhaps non-feasible) reform. Historical evidence gives some indication of the scope for change. Kenny and Schmidt (1994) charted school district numbers and private

[19] The voucher studies of Peterson et al. (2000) report effect sizes of approximately 0.2. The Tennessee Class Size experiment found effect sizes of approximately 0.2; and the Milwaukee Parental Choice

schooling enrollments for the decades 1949-50 to 1980-81. During this period, the number of school districts fell by 126%, 106%, and 12%; this represents a mean annual change of –8.1%. To reverse this sustained trend, and so promote competition, would require substantial structural reform or political commitment. In contrast, the proportions in private schooling remained reasonably static over the four decades (at 10.91%, 12.13%, 9.14%, and 9.04%). So, for evaluating the effects of tuition tax credits or vouchers, a plausible annual increase in private schooling enrollments might therefore be no more than 2 percentage points (the mean annual change in absolute terms is 1.46%). This contrasts with a one standard deviation increase in private schooling (applied as the metric in the above protocol), of around 7 percentage points.

In summarizing this evidence, the benefits of competition listed in Appendix Tables A1–A4 should not be exaggerated. A number of them may in fact be the 'same' benefit, but calculated in a different way: the effects of competition on higher test scores, for example, may pass through into higher wages. Although the evidence gains plausibility in that it triangulates well, the effects of competition in Table 1 cannot be aggregated.

Finally, the equity of increasing competition needs to be considered. The evidence above suggests that competition has the strongest effects for low-income students. The modest gains may therefore be given a higher weight, where they serve a re-distributive function. However, there is evidence from voucher programs that higher income families benefit most when choice sets are expanded (Witte, 1999). Evaluation of competition thus depends on who takes advantage of choice, times the pay-off to those who are able to choose.

Program found effect sizes of approximately 0.1.

5.3 *The Costs of Increased Competition*

The costs of an education system may also change where more competition is being promoted, and such costs may offset the benefits of competitive reforms (for vouchers, see Levin and Driver, 19970. There is limited evidence on how much it costs to foster, regulate, and monitor competition, and on how to maintain competition (over collusion); but, the argument that competition reform is costless in comparing it with other reforms as assumed by Mayer and Peterson (1999, pp 352–353) is unsubstantiated.

As well, there are three other important unknowns in interpreting this evidence. One is the duration over which increased competition has effects; another relates to the threshold impact of competition; and the third unknown relates to equity and social cohesion. So, the substantive benefits (e.g. in terms of test scores) may arise only where increased competition has been sustained over a schooling duration. If so, any cost–benefit calculation will have to take account of the long lag before any benefits from competition are realized. Regarding the thresholds, the evidence suggests that competition is non-linear: the effects are only detectable in very concentrated markets. Any practical policy would therefore require reform in these very concentrated markets, with little effect being anticipated for markets that are already weakly concentrated. Finally, the notion that competition is equity-enhancing and socially cohesive may be challenged. Market education systems may rank poorly against equity criteria (e.g., with greater segregation and partitioning of student groups, Levin, 2001; Carnoy, 2000). Relatedly, the effects on social cohesion are unknown. Competition may deliver higher technical efficiency, but lower output efficiency, i.e. fail to produce the types of outcomes most valued by society. So, public schools might supply fewer of the social benefits of education, if they are in greater competition with private schools that focus on human capital generation (Manski, 1992).

6. Conclusion

The above evidence shows reasonably consistent evidence of a link between competition (choice) and education quality. Increased competition and higher educational quality are positively correlated. To an economist, this conclusion is highly plausible. However, this simple summary fails to capture another important conclusion from the evidence: the effects of competition on educational outcomes appear substantively modest and between one-third and two-thirds of the estimates lack statistical significance. This conclusion too might be thought as equally plausible: after all, many factors determine the quality of education provision. Finally, it is the actual benefits – set against any additional induced costs – that must be used to justify specific approaches to generating greater educational productivity.

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Table 1 **Summary of the Effects of Increases in Competition by One Standard Deviation**

Outcome Variable	Stat. Sig. Estimations (t)[a]	Competition Measure	Effect of Increasing Competition by 1 Standard Deviation
Academic outcomes	40.6% (*190*)	Herfindahl Index	Outcome scores in public schools rise by 0.1 s.d.
		Private school enrollments	Outcome scores in public schools rise by <0.1 s.d.
		Other proxies for competition	Outcome scores in public schools rise by <0.1 s.d.
Attainment, graduation rates, drop-out rates	53.7% (*51*)	Number of districts or schools	Drop-out rates are not affected
		Private school enrollments	Graduation rates are higher by 0.08–0.18 s.d.
Spending	66.7% (*32*)	Number of districts in state	Spending is lower by 12%
		Private school enrollments	Spending effect is ambiguous (higher by 0.2–0.4 s.d. *or* lower by 7%)
Efficiency	66.7% (*54*)	Herfindahl Index	Efficiency is higher, only in concentrated markets
		Private school enrollments	Efficiency is higher, by approximately 0.2 s.d.
Teaching quality	60.0% (*30*)	Private school enrollments	Teacher salaries rise by 0.1-0.3 s.d. ($400–$1000) Student–teacher ratios are lower, by at most 1 student
Private school enrollments	36.0% (*26*)	Public school quality	Private school enrollments fall by 0-0.17 s.d.
Wages	41.2% (*17*)	Private school enrollments	Wages rise by 0.1 s.d. (1%–4% higher)

Notes: [a] Number of separate studies: academic outcomes, 26; attainment, graduation rates, drop-out rates, 7; spending, 11; efficiency, 12; teaching quality, 8; private school enrollments, 4; wages, 3. Also, the estimations on housing prices are excluded, because the number of studies is too low (1).

Table A1

The Effects of Competition on Academic Outcomes

Source	Data	Dependent variable [mean, s.d.]	Independent variable [mean, s.d.]	Estimation method	Coeff (|t|) for independent variable	
Borland & Howson (1992)	Ken., 1989-90, *n*=170	Dist. mean test scores, 3rd gr: R, LG, M [na]	HI [na]	2SLS teacher salary	-2.12 (1.43)	nsd
Borland & Howson (1995)	Ken., 1995, *n*=170	Dist. mean test scores, 3rd gr: M [na]	HI [na]	2SLS teacher salary	-2.42 (1.39)	nsd
Hanushek & Rivkin (2001)	UTD Texas MSAs, 1993-94 *n*=27	MSA school average test score gains between cohorts 4-6 gr: M [0, 1]	Herfindahl Index [na, 0.02]	Fixed effects for MSAs, based on student migration	Scatterplot	nsd
	UTD Texas Schools, 1993-94 *n*=1140	Between cohort variance in school average test score gains (as a measure of variance in teacher quality)	Herfindahl Index * % different teachers [na]	FE[a]	1.35 (2.60)	**
				FE[b]	1.18 (2.38)	**
				FE[c]	2.05 (2.01)	**
	UTD Texas Schools, 1993-94 *n*=306	Between cohort variance in school average test score gains for schools with >75% FSL		FE[a]	1.15 (2.50)	**
				FE[b]	0.97 (3.71)	**
				FE[c]	1.19 (2.11)	**
	UTD Texas Schools, 1993-94 *n*=272	Between cohort variance in school average test score gains for schools with <25% FSL		FE[a]	-0.18 (1.07)	nsd
				FE[b]	-0.08 (0.55)	nsd
				FE[c]	0.06 (0.21)	nsd
	UTD Texas Districts, 1993-94 *n*=832	Between cohort variance in Dist. average test score gains		FE[a]	0.11 (1.25)	nsd
				FE[b]	0.06 (0.93)	nsd
				FE[c]	-0.28 (1.56)	nsd
Marlow (2000)	Calif., 1993, Counties *n=54*	4th gr: R [21.58, 5.47]	HI [0.32, 0.29]	SUR[a]	-4.13 (2.46)	**
				SUR[b]	-3.34 (2.03)	**
		4th gr: WR [30.35, 7.86]	HI [0.32, 0.29]	SUR[a]	-3.38 (1.66)	*
				SUR[b]	-2.62 (1.31)	nsd
		4th gr: M [29.23, 7.66]	HI [0.32, 0.29]	SUR[a]	-1.45 (0.71)	nsd
				SUR[b]	-0.38 (0.19)	nsd
		8th gr: R [40.37, 8.87]	HI [0.31, 0.28]	SUR[a]	-12.89 (4.05)	***
				SUR[b]	-12.22 (3.88)	***
		8th gr: WR [47.23, 8.79]	HI [0.31, 0.28]	SUR[a]	-6.83 (2.37)	**
				SUR[b]	-7.51 (2.53)	**
		8th gr: M [25.25, 8.37]	HI [0.31, 0.28]	SUR[a]	-10.85 (4.25)	***
				SUR[b]	-11.97 (5.10)	***
		10th gr: R[32.60, 7.70]	HI [0.42, 0.27]	SUR[a]	-1.89 (0.54)	nsd
				SUR[b]	-1.37 (0.39)	nsd
		10th gr: WR[38.82, 7.86]	HI [0.42, 0.27]	SUR[a]	3.78 (1.07)	nsd
				SUR[b]	2.76 (0.77)	nsd
		10th gr: M [15.09, 5.51]	HI [0.42, 0.27]	SUR[a]	1.57 (0.72)	nsd

				SUR[b]	2.43 (1.11)	nsd
Borland & Howson (1993)	Ken., 1989-90, n=170	Dist. mean test scores, 3rd gr: R, LG, M [na]	HI critical value [na]	Switching regime, 2SLS	-1.61 (1.97)	**
Zanzig (1997)	Calif., 1970-1, n=337	Dist. mean scores, ITED score 12 gr: M [12.78, 1.99]	Below-competitive threshold of districts in the county [3.783, 0.644]	2SLS[a]	0.305 (1.93)	*
				OLS[a]	0.145 (1.51)	nsd
				2SLS[b]	0.298 (1.98)	**
				2SLS[c] IV: teacher salary	0.232 (2.34)	**
			Above competitive HI threshold of 0.58 [0.018, 0.079]	2SLS[a]	-2.318 (1.59)	nsd
				OLS[a]	-1.402 (2.38)	**
				2SLS[b]	-1.453 (2.22)	**
				2SLS[c] IV: teacher salary	1.127 (1.78)	*
Figlio and Stone (1999)	NELS, n=13541	Difference in Ln 10 gr. M score religious private school over public school	Public school concentration below the median	IV: school type	-0.045 (0.026)	*
			Public school concentration above the median		-0.012 (0.028)	Nsd
		Difference in Ln 10 gr. M score non-religious private school over public school	Public school concentration below the median		-0.019 (0.026)	Nsd
			Public school concentration above the median		0.036 (0.025)	nsd
Simon & Lovrich (1996)	Washington state 1990, n=104, districts, Census data	4 gr: M [na]	Dist. private school enrlmt [na]	OLS, Controls for parental education, $ spent per pupil, Dist. wealth	0.18 (2.91)	***
		8 gr: M [na]			0.03 (0.44)	Nsd
		4 gr: R [na]			0.10 (1.39)	Nsd
		8 gr: R [na]			-0.01 (0.15)	Nsd
		4 gr: V [na]			0.08 (0.09)	Nsd
		8 gr: V [na]			-0.001 (0.01)	nsd
Couch, Shughart and Williams (1993)	North Carolina counties, 1988-89, n=100	Z Score Test, 8-12 gr: Al [0, 1]	County private school enrlmt [2.99, 2.72]	2SLS[a]	0.078 (2.02)	**
				2SLS[b] private enrlmt	0.090 (2.23)	**
Newmark (1995)	North Carolina counties, 1988, 89, 90, n=100	Z Score, 8-12 gr: Al [0, 1]	County private school enrlmt [3.13, 2.86]	OLS, funding adjusted for	0.0842 (2.20)	**
		Z Score, 8-12 gr: M [0, 1]			0.0360 (0.98)	nsd
		Z Score, 8-12 gr: X1 [0, 1]			0.0285 (0.71)	nsd
		Z Score, 8-12 gr: X2 [0, 1]			-0.0341 (0.87)	nsd
		Z Score, 8-12 gr: X3 [0, 1]			-0.0198 (0.49)	nsd
		Z Score, 8-12 gr: X4 [0, 1]			-0.0027 (0.07)	nsd
		Z Score, 8-12 gr: X5 [0, 1]			0.0392 (0.93)	nsd
		Z Score, 8-12 gr: X5 [0, 1]			-0.0307 (0.74)	nsd
		Z Score, 8-12 gr: X6 [0, 1]			0.0126 (0.47)	nsd
		Z Score, 8-12 gr: Al [0, 1]	County private school enrlmt, Census data [na]		0.0155 (0.47)	nsd
		Z Score, 8-12 gr: Al [0, 1]	Only non-religious private school enrlmt [na]		0.0219 (0.46)	nsd
		Z Score, 8-12 gr: Al [0, 1]	County private school enrlmt [3.13, 2.86]		0.0076 (0.13)	nsd
		Yield, 8-12 gr: Al [0, 1]			-0.2884 (1.02)	nsd

Sander (1999)	Illinois BoE, 1996, schools, n=1754	6 gr: M [270.9, 56.9]	Private school enrlmt [15.8, 8.7]	2SLS, Catholic popn	-0.38 (0.68)	nsd
		10 gr: M [258.5, 47.0]		density	1.03 (0.60)	nsd
McMillan (1998)	NELS, 1988, n=738 schools	Log public school average score 8 gr: R [3.9, 0.089]	Dist. private school enrlmt [0.118, 0.072]	WLS	-0.075 (2.08)	**
				IV[a]	-0.216 (1.33)	nsd
				IV[b]	-0.061 (0.63)	nsd
				3SLS[a]	-0.244 (1.52)	nsd
				3SLS[b]	0.042 (0.30)	nsd
				3SLS[c]	-0.194 (1.53)	nsd
				3SLS[d]	-0.828 (15.92)	***
				No funding adjustment		
			Dist. private school enrlmt [0.118, 0.072]	3SLS[c]	0.688 (1.51)	nsd
			Dist. private school enrlmt * parental involvement [na]		-5.259 (2.58)	**
				No funding adjustment		
			Dist. private school enrlmt [0.118, 0.072]	3SLS[f]	0.662 (1.83)	nsd
			Dist. private school enrlmt * parental involvement [na]		-3.425 (2.15)	**
	NELS, 1988, n=842 schools	Log public school average score 10 gr: R [na]	Dist. private school enrlmt [0.118, 0.072]	IV, 10 gr	-0.370 (1.98)	*
					-0.431 (1.63)	nsd
	NELS, 1988, n=4356 individuals	Log public school average score 10 gr: R [na]	Dist. private school enrlmt [0.118, 0.072]	IV, 10 gr	-0.449 (2.49)	**
Smith & Meier (1995)	Florida, panel of districts, 1986-90, n=198	% public school students pass rate: M [na]	Lagged private school enrollment [na]	OLS	-0.370 (1.76)	*
				GLS,	-0.429 (na)	**
				Year FE, Controls:	-0.348 (na)	nsd
				%Catholic, family income	-0.264 (na)	nsd
		% public school students pass rate: X [na]		OLS	-0.227 (2.39)	**
				GLS,	-0.315 (na)	**
				Year FE, Controls:	-0.299 (na)	**
				%Catholic, family income	-0.289 (na)	**
Maranto, Milliman & Stevens (2000)	Florida, panel of districts, 1986-90, n=198, high-income=32, low-income=33	% Dist. public school students pass rate high-income 5 gr: C	Private school enrollment [7.9, na]	OLS	-0.21 (-0.66)	nsd
		% Dist. public school students pass rate high-income 8 gr: C [na]			-1.18 (2.83)	**
		% Dist. public school students pass rate high-income 10 gr: C [pooled:88.2, 4.8]			0.67 (2.04)	*
		% Dist. public school students pass rate low-income 5 gr: C [na]	Private school enrollment [2.7, na]	OLS	-0.6 (1.59)	Nsd
		% Dist. public school students pass rate low-income 8 gr: C [na]			-0.97 (2.61)	**

		% Dist. public school students pass rate low-income 10 gr: C [pooled:88.2, 4.8]			-0.26 (0.74)	nsd
		% Dist. public school students pass rate high-income 5 gr: M [na]	Private school enrollment [7.9, na]	OLS	0.47 (1.68)	nsd
		% Dist. public school students pass rate high-income 8 gr: M [na]			-1.13 (2.36)	**
		% Dist. public school students pass rate high-income 10 gr: M [pooled:81.3, 6.9]			0.65 (1.71)	*
		% Dist. public school students pass rate low-income 5 gr: M [na]	Private school enrollment [2.7, na]	OLS	-0.98 (2.88)	Nsd
		% Dist. public school students pass rate low-income 8 gr: M [na]			-1.14 (2.31)	**
		% Dist. public school students pass rate low-income 10 gr: M [pooled:81.3, 6.9]			-0.73 (1.56)	nsd
		Dist. public school pass rate 10 gr: C [88.2, 4.8]	Private school market share: lagged 1 year [na]	OLS, Income variable corrected for inflation	-0.19 (1.90)	**
		Dist. public school pass rate high-income 10 gr: C [na]			-0.298 (1.89)	*
		Dist. public school pass rate low-income 10 gr: C [na]			-0.086 (1.00)	nsd
Arum (1996)	HSB, individuals *n*=6910	Test scores 12 gr: M, RD, V [42.30, 15.41]	% private schooling [9.6, 4.79]	OLS[a]	0.057 (2.85)	***
				OLS[b]	0.056 (2.80)	***
				OLS[c]	0.038 (1.81)	nsd
				OLS[d]	0.047 (2.04)	**
				OLS[e]	0.050 (2.17)	**
				OLS[f]	0.026 (1.00)	nsd
				Controls: 10th gr, SES, school SES (c controls for public school resources)		
Marlow (1997)	DES, 1990, Cross-state, *n*=50	12th gr SAT: M [na]	Districts per 1000 stud. [na]	SUR	10.0 (3.81)	***
		12th gr SAT: M [na]	Schools per 1000 stud. [na]	SUR	4.25 (2.19)	***
		12th gr SAT: VB [na]	Districts per 1000 stud. [na]	SUR	4.10 (1.52)	*
		12th gr SAT: VB [na]	Schools per 1000 stud. [na]	SUR	3.05 (1.63)	*
		8th gr Proficiency: M [na]	Districts per 1000 stud. [na]	SUR	7.91 (5.65)	***
		8th gr Proficiency: M [na]	Schools per 1000 stud. [na]	SUR	6.42 (6.29)	***
Blair & Staley (1995)	Ohio, 1991, *n=266*	Dist. test scores 4th, 6th, 8th gr: R, M and A [54.61, 6.02]	Average adjacent Dist. scores [54.63, 6.02]	OLS	0.41 (5.37)	***
			Districts bordering own district [5.60, 2.03]	OLS	-0.80 (0.63)	nsd

Jepsen (1999)	Individuals NLS, 1972, n=13653	Standardised test: M [50.25, 9.99]	Distance to nearest Catholic school [17.86, 28.46]	OLS	-0.0002 (0.05)	nsd
				IV, Catholic popn density	0.0050 (2.18)	**
			Private school enrlmt: county [10.46, 7.61]	OLS	-0.0067 (0.33)	nsd
				IV, Catholic popn density	0.0855 (2.05)	**
			Private school enrlmt: MSA [9.91, 6.38]	OLS	-0.0009 (0.04)	nsd
				IV, Catholic popn density	0.0560 (1.10)	nsd
Jepsen (1999)	NELS, 1988 n=11136	Standardised test: M [47.85, 14.45]	Distance to nearest Catholic school [19.71, 27.41]	OLS	0.0004 (0.05)	nsd
				IV, Catholic popn density	-0.0768 (1.15)	nsd
			Private school enrlmt by zip [9.51, 8.72]	OLS	-0.0222 (0.78)	nsd
				IV, Catholic popn density	-0.1225 (1.87)	*
			Private school enrlmt by county [9.26, 5.59]	OLS	-0.0505 (0.91)	nsd
				IV, Catholic popn density	-0.1394 (1.28)	nsd
			Private school enrlmt by MSA [9.38, 4.98]	OLS	-0.0351 (0.53)	nsd
				IV, Catholic popn density	-0.1003 (0.64)	nsd
Hoxby (2001)	NELS, students n=10790	8th gr R [50, 10]	% MA students enrolled in private school	IV, Catholic population	0.271 (3.01)	***
	NELS, students n=7776	10th gr M [50, 10]	% MA students enrolled in private school	IV, Catholic population	0.249 (2.77)	***
	NELS, students n=6119	12th gr R [50, 10]	% MA students enrolled in private school	IV, Catholic population	0.342 (1.99)	**
	NELS, students	12 gr.: M [50, 10]	% MA students enrolled in private school	IV, Catholic population	0.371 (2.17)	**
Hoxby (1994)	NLSY	AFQT percentile score [40.9, 28.7]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV	0.190 (2.11)	**
				FGLS	-0.080 (1.33)	nsd
Hoxby (2000a)	Census, MAs, n=211, NELS students, n=10790	12 gr: R [50, 10]	Dist. choice (enrlmt-based) [0.686, 0.271]	OLS	-1.434 (2.21)	**
				IV[a]	5.77 (2.61)	***
				IV[b]	6.084 (2.67)	***
				IV[c] natural boundaries	7.149 (1.48)	nsd
			Dist. choice (enrlmt-based) * low income family	IV[a]	4.35 (1.89)	*
			Dist. choice (enrlmt-based) * high income family	IV[a]	5.81 (2.52)	**
			Dist. choice (enrlmt-based) * minority status	IV[a]	4.234 (1.00)	Nsd
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	6.096 (2.76)	***
			Dist. choice based on land area [0.761, 0.269]	IV[a]	5.803 (2.66)	**
			Index of school choice, based on enrollment [0.974, 0.069]	IV[a]	-130.58 (1.36)	Nsd
Hoxby (2000a)	Census, MAs, n=211, NELS students, n=7776	8 gr: R [50, 10]	Dist. choice (enrlmt-based) [0.686, 0.271]	OLS	-0.236 (0.48)	Nsd
				IV[a]	3.818 (2.40)	**
				IV[b]	4.649 (2.91)	***
				IV[c] natural boundaries	5.137 (1.50)	nsd

			Dist. choice (enrlmt-based) * low income family	IV[a]	3.364 (1.89)	*
			Dist. choice (enrlmt-based) * high income family	IV[a]	4.028 (2.24)	**
			Dist. choice (enrlmt-based) * minority status	IV[a]	-0.376 (0.14)	Nsd
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	4.589 (2.72)	***
			Dist. choice based on land area [0.761, 0.269]	IV[a]	4.761 (3.33)	***
			Index of choice of schools, based on enrollment [0.974, 0.069]	IV[a]	61.38 (1.39)	Nsd
Hoxby (2000a)	Census, MAs, n=211, NELS students, n=6119	10 gr: M [50, 10]	Dist. choice (enrlmt-based) [0.686, 0.271]	OLS	-0.733 (1.30)	Nsd
				IV[a]	3.061 (2.05)	**
				IV[b]	2.573 (1.74)	*
				IV[c]	2.663 (0.78)	nsd
				natural boundaries		
			Dist. choice (enrlmt-based) * low income	IV[a]	2.825 (1.60)	*
			Dist. choice (enrlmt-based) * high income	IV[a]	3.043 (1.74)	*
			Dist. choice (enrlmt-based) * minority	IV[a]	-2.83 (0.79)	Nsd
			Dist. choice (enrlmt-based) * non-minority	IV[a]	5.116 (2.89)	***
			Dist. choice based on land area [0.761, 0.269]	IV[a]	2.875 (1.93)	*
			Index of choice of schools, based on enrollment [0.974, 0.069]	IV[a]	-57.41 (1.08)	Nsd
Hoxby (2000a)	Census, MAs, n=218, NLSY students, n=7112	ASVAB test: M [50, 10]	Dist. choice (enrlmt-based) [0.686, 0.271]	OLS	2.024 (3.61)	***
				IV[a]	2.747 (1.75)	*
				IV[c]	2.86 (0.62)	nsd
				natural boundaries		
			Dist. choice (enrlmt-based) * low income	IV[a]	4.148 (2.54)	**
			Dist. choice (enrlmt-based) * high income	IV[a]	5.639 (3.25)	***
			Dist. choice (enrlmt-based) * minority	IV[a]	5.485 (2.09)	**
			Dist. choice (enrlmt-based) * non-minority	IV[a]	2.907 (1.70)	Nsd
			Dist. choice based on land area [0.761, 0.269]	IV[a]	2.855 (1.79)	Nsd
			Index of choice of schools, based on enrollment [0.974, 0.069]	IV[a]	-18.832 (0.79)	nsd
Geller, Sjoquist and Walker (2001)	Georgia school districts, 1980-90, n=178	10 gr. R	% of 10th gr. in private school [4.79, 5.31]	2SLS (lagged effects) & IV	-0.137 (2.52)	**
			Public 10th gr schools in near counties [15.5, 14.83]		0.017 (1.99)	**
			% of 10th grade schools are private [36.4, 26.1]		-0.023 (1.26)	nsd
		10 gr. M	% of 10th gr. in private school [4.79, 5.31]		-0.125 (2.15)	**
			Public 10th gr schools in near counties [15.5, 14.83]		0.014 (1.50)	nsd
			% of 10th grade schools private [36.4, 26.1]		-0.024 (1.20)	nsd
		3 gr. R	% of 3rd gr. in private school [4.43, 5.44]	2SLS (lagged effects) & IV	-0.018 (1.03)	Nsd
			Public 3rd gr schools in near counties [47.14, 55.17]		-0.004 (0.53)	Nsd
			% of 3rd grade schools that are private [25.77, 19.8]		0.018 (0.17)	Nsd
		3 gr. M	% of 3rd gr. in private school [4.43, 5.44]		-0.007 (0.35)	Nsd
			Public 3rd gr schools in near counties [47.14, 55.17]		-0.008 (0.96)	Nsd
			% of 3rd grade schools that are private [25.77, 19.8]		-0.017 (0.19)	nsd

Table A2

The Effects of Competition on Attainment and Graduation Rates

Source	Data	Dependent variable [mean, s.d.]	Independent variable [mean, s.d.]	Estimation method	Coeff. (|t|)	Signif.
Dee (1998)	CCD, 1993-94, Districts, n=4488	Dist. high school graduation rates [88.1, 9.6]	% students in county private schools [7.5, 7.6]	OLS[a]	0.042 (2.2)	**
				OLS[b]	-0.011 (0.6)	nsd
				OLS[c]	-0.023 (1.2)	nsd
				2SLS[a]	0.295 (4.9)	***
				2SLS[b]	0.268 (4.4)	***
				2SLS[c]	0.228 (3.8)	***
				IV: Catholic population		
Sander (1999)	Illinois BoE, 1996, schools, n=1754	Graduation rate [83.7, 11.7]	Private school attendance [9.9, 8.1]	2SLS, Catholic	0.16 (0.15)	nsd
		College bound [61.1, 14.2]		population density	0.41 (0.27)	nsd
Marlow (1997)	DES, 1990, Cross-state, n=50	drop-out rate [na]	Districts per 1000 stud. [na]	SUR	-1.41 (3.67)	***
			Schools per 1000 stud. [na]	SUR	-1.16 (4.56)	***
Jepsen (1999)	NELS, 1988 n=9831	College attendance [0.73, 0.44]	Dist. To Cath. School [19.71, 27.41]	OLS	-0.0001 (0.33)	nsd
				IV, Cath. Popn density	-0.0023 (1.15)	nsd
			Zip private schooling zip [9.51, 8.72]	OLS	0.0014 (1.40)	nsd
				IV, Cath. Popn density	0.0021 (1.05)	nsd
			County private schooling [9.26, 5.59]	OLS	0.0044 (2.44)	**
				IV, Cath. Popn density	0.0110 (3.33)	***
			MSA private schooling [9.38, 4.98]	OLS	0.0053 (2.21)	*
				IV, Cath. Popn density	0.0066 (1.53)	nsd
	NELS, 1988 n=13697	High school graduation [0.78, 0.42]	Dist. To Cath. School [19.71, 27.41]	OLS	-0.0001 (0.33)	nsd
				IV, Cath. Popn density	-0.0026 (1.08)	nsd
			Zip private schooling zip [9.51, 8.72]	OLS	0.0012 (1.33)	nsd
				IV, Cath. Popn density	-0.0050 (2.00)	**
			County private schooling [9.26, 5.59]	OLS	0.0007 (0.35)	nsd
				IV, Cath. Popn density	-0.0008 (0.20)	nsd
			MSA private schooling [9.38, 4.98]	OLS	0.0045 (1.96)	*
				IV, Cath. Popn density	0.0023 (0.55)	nsd
	Individuals NLS, 1972, n=13653	Years of schooling after High School [1.64, 1.73]	Dist. To Cath. School [19.71, 27.41]	OLS	-0.0005 (0.83)	nsd
				IV, Cath. Popn density	0.0072 (1.31)	nsd

			County private schooling [9.26, 5.59]	OLS	0.0013 (0.41)	nsd
				IV, Cath. Popn density	0.0054 (0.83)	nsd
			MSA private schooling [9.38, 4.98]	OLS	0.0036 (0.95)	nsd
				IV, Cath. Popn density	0.0009 (0.12)	nsd
Hoxby (1994)	NLSY, 1990, n=10589	Highest grade completed by age 24 [12.3, 2.2]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	FGLS	-0.01 (1.00)	nsd
				IV, Catholic popn	0.033 (2.75)	***
Hoxby (1994)	NLSY, 1990, n=10589	Highest grade completed by age 24 [12.3, 2.2]	% county secondary school enrollment in private schools [7.57, 5.10]	FGLS	0.01 (1.00)	nsd
				IV, Religious densities	0.035 (2.50)	**
		High school diploma [0.71, 0.45]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV	0.002 (2.00)	**
				FGLS	-0.0005 (1.25)	nsd
		2 years of college by 24 [0.25, 0.43]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV	0.003 (3.00)	***
				FGLS	0.003 (3.00)	***
		4 year college graduate by 24 [na]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV	0.003 (3.00)	***
				FGLS	0.004 (4.00)	***
Hoxby (2000a)	Census, MAs, n=221, NLSY students, n=7538	Highest grade attained [13.93, 2.86]	Dist. choice (enrlmt-based) [0.686, 0.271]	OLS	0.323 (2.15)	**
				IV[a]	1.381 (2.94)	***
				IV[c] natural boundaries	1.285 (1.05)	nsd
			Dist. choice (enrlmt-based) * low income family	IV[a]	1.564 (3.50)	***
			Dist. choice (enrlmt-based) * high income family	IV[a]	1.708 (3.61)	***
			Dist. choice (enrlmt-based) * minority status	IV[a]	1.835 (2.51)	**
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	1.267 (2.22)	*
			Dist. choice based on land area [0.761, 0.269]	IV[a]	1.516 (2.93)	***
			Index of choice of schools, based on enrollment [0.974, 0.069]	IV[a]	8.031 (0.67)	nsd

Table A3

The Effects of Competition on Spending and Efficiency

Source	Data	Dependent variable [mean, s.d.]	Independent variable [mean, s.d.]	Estimation method	Coeff. (|t|)	Signif.
		SPENDING:				
Schmidt (1992)	NCES, Census, 1980, MSA n=129	Per pupil expenditure in public schools in MSA [1856, 342]	Predicted fraction in private schools (log) [na]	IV	0.161 (3.84)	***
Lovell (1978)	Census, 1970, cities, n=75	Per pupil expenditure in public schools [843, 153]	Proportion of students in private schools	OLS	-0.006 (0.04)	nsd
Burnell (1991)	Census, 1988, Counties, n=280	Per pupil expenditure in public schools in county [na]	Number of school districts in county [na]	OLS[a]	0.035 (4.92)	***
				OLS[b]	0.033 (4.90)	***
Marlow (1997)	DES, 1990, Cross-state, n=50	spending per pupil [na]	Districts per 1000 stud. [na]	SUR	11.46 (0.40)	nsd
		spending per pupil [na]	Schools per 1000 stud. [na]	SUR	59.34 (3.23)	***
		Spending: % of GSP [na]	Districts per 1000 stud. [na]	SUR	0.04 (0.48)	nsd
		Spending: % of GSP [na]	Schools per 1000 stud. [na]	SUR	0.10 (1.62)	*
Marlow (2000)	Calif., 1993, Counties n=54	Spending per student 4th gr [4189, 297.13]	HI [0.32, 0.29]	SUR	545.92 (2.65)	***
		Spending per student 8th gr [4189, 297.13]	HI [0.31, 0.28]	SUR	626.84 (2.96)	***
		Spending per student 10th gr [4189, 297.13]	HI [0.42, 0.27]	SUR	580.02 (2.54)	**
		Spending: % personal income 4th gr [4.22, na]	HI [0.32, 0.29]	SUR	0.57 (2.05)	**
		Spending: % personal income 8th gr [4.22, na]	HI [0.31, 0.28]	SUR	0.57 (1.98)	**
		Spending: % pers. Income 10th gr [4.22, na]	HI [0.42, 0.27]	SUR	0.71 (2.36)	**
Kenny and Schmidt (1995)	Census data, across states, 1950-80 n=198	Per pupil expenditure [na]	Less competition (dummy variable if no of school districts less than 25th %tile)	2SIS[a]	68.47 (2.84)	***
				2SLS[b] no adjustment for outcomes	31.47 (1.26)	nsd
Arum (1996)	States, Census, 1980, n=50	Public school expenditure per student per $1000 [2.24, 0.58]	% private schooling [9.6, 4.79]	OLS[a]	0.027 (2.70)	***
				OLS[b]	0.032 (3.56)	***

Goldhaber (1999)	New York state, panel of districts, 1981-91, n=5580	Public school expenditure per student [2019, 701; 1983$]	% private school enrollment [18.32, 16.14]	OLS[a] OLS[b] 2SLS[a] 2SLS[b] Controls for Dist. aid/pupil	477.660 (12.37) -11.383 (0.12) 337.527 (5.23) -122.032 (0.75)	*** nsd *** nsd
Hoxby (1994)	N=947	County per-pupil spending in public schools [2199, 517; 1990$]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV FGLS	-18.77 (1.24) -2.91 (0.46)	Nsd Nsd
Hoxby (1994)	N=947	County per-resident spending in public schools [na]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV FGLS	-7.12 (2.55) -2.46 (2.10)	** **
Hoxby (2000a)	CCD, Districts, n=6523	Log per-pupil spending [8.46, 0.26]	Enrollment based choice [0.77, 0.24]	OLS IV[a] IV[b] IV[c]	-0.072 (3.27) -0.076 (2.24) -0.058 (1.76) -0.064 (1.31)	*** ** * nsd
			Choice based on Dist. land area	IV[a]	-0.101 (2.35)	**
			Choice based on school enrollment	IV[a]	-0.803 (0.86)	nsd
		EFFICIENCY:				
Hoxby (2000a)	NELS, students	Productivity: 8th gr R achievement over log per-pupil spending [5.92, 1.18]	Index of inter-district choice	IV, natural boundaries	0.290 (2.07)	**
			Dist. choice (enrlmt-based) * low income family	IV[a]	0.227 (1.31)	Nsd
			Dist. choice (enrlmt-based) * high income family	IV[a]	0.312 (1.94)	**
			Dist. choice (enrlmt-based) * minority status	IV[a]	-0.141 (0.41)	Nsd
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	0.374 (2.41)	**
			Dist. choice (enrlmt-based) * mostly state control	IV[a]	0.110 (0.61)	Nsd
			Dist. choice (enrlmt-based) * mostly local control	IV[a]	0.290 (1.78)	*
Hoxby (2001)	NELS, students n=10790	Productivity: 8th gr R achievement over log per-pupil spending [5.92, 1.18]	% MA students enrolled in private school	IV, Catholic population	0.027 (3.00)	***
Hoxby (2000a)	NELS, students	Productivity: 10th gr M achievement over log per-pupil spending [5.92, 1.18]	Index of inter-district choice	IV, natural boundaries	0.308 (1.95)	*
			Dist. choice (enrlmt-based) * low income family	IV[a]	0.268 (1.47)	Nsd

			Dist. choice (enrlmt-based) * high income family	IV[a]	0.298 (1.76)	*
			Dist. choice (enrlmt-based) * minority status	IV[a]	-0.157 (0.41)	Nsd
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	0.556 (3.05)	***
			Dist. choice (enrlmt-based) * mostly state control	IV[a]	0.323 (1.87)	Nsd
			Dist. choice (enrlmt-based) * mostly local control	IV[a]	0.357 (2.23)	**
Hoxby (2001)	NELS, students #=7776	Productivity: 10th gr M achievement over log per-pupil spending [5.94, 1.18]	% MA students enrolled in private school	IV, Catholic population	0.025 (2.78)	***
Hoxby (2000a)	NELS, students	Productivity: 12th gr R achievement over log per-pupil spending [5.96, 1.17]	Index of inter-district choice	IV, natural boundaries	0.579 (2.45)	**
			Dist. choice (enrlmt-based) * low income family	IV[a]	0.406 (1.54)	Nsd
			Dist. choice (enrlmt-based) * high income family	IV[a]	0.572 (2.17)	**
			Dist. choice (enrlmt-based) * minority status	IV[a]	0.428 (1.02)	Nsd
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	0.595 (2.06)	**
			Dist. choice (enrlmt-based) * mostly state control	IV[a]	0.469 (1.91)	*
			Dist. choice (enrlmt-based) * mostly local control	IV[a]	0.6 (2.45)	**
Hoxby (2001)	NELS, students #=6119	Productivity: 12th gr R achievement over log per-pupil spending [5.96, 1.17]	% MA students enrolled in private school	IV, Catholic population	0.035 (2.06)	**
Hoxby (2000a)	NELS, students	Productivity: 12th gr M achievement over log per-pupil spending [5.96, 1.26]	Index of inter-district choice	IV, natural boundaries	0.516 (2.55)	**
			Dist. choice (enrlmt-based) * low income family	IV[a]	0.513 (2.66)	***
			Dist. choice (enrlmt-based) * high income family	IV[a]	0.619 (3.03)	***
			Dist. choice (enrlmt-based) * minority status	IV[a]	0.695 (2.24)	**
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	0.417 (1.70)	*
			Dist. choice (enrlmt-based) * mostly state control	IV[a]	0.304 (1.40)	Nsd
			Dist. choice (enrlmt-based) * mostly local control	IV[a]	0.415 (2.04)	**
Hoxby (2001)	NELS, students	Productivity: 12th gr M achievement over log per-pupil spending [5.97, 1.26]	% MA students enrolled in private school	IV, Catholic population	0.038 (2.24)	**
Hoxby (2000a)	NLSY, CCD	Productivity: highest grade attained [1.64, 0.44]	Index of inter-district choice	IV, natural boundaries	0.215 (3.84)	***
			Dist. choice (enrlmt-based) * low income family	IV[a]	0.213 (4.02)	***
			Dist. choice (enrlmt-based) * high income family	IV[a]	0.224 (4.00)	***

			Dist. choice (enrlmt-based) * minority status	IV[a]	0.277 (3.18)	***
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	0.164 (2.41)	**
			Dist. choice (enrlmt-based) * mostly state control	IV[a]	0.254 (4.79)	***
			Dist. choice (enrlmt-based) * mostly local control	IV[a]	0.302 (5.39)	***
Hoxby (2000a)	NELS	Productivity: ln(income) at age 32	Index of inter-district choice	IV, natural boundaries	0.077 (2.75)	***
			Dist. choice (enrlmt-based) * low income family	IV[a]	0.053 (1.96)	**
			Dist. choice (enrlmt-based) * high income family	IV[a]	0.092 (3.07)	***
			Dist. choice (enrlmt-based) * minority status	IV[a]	0.096 (2.13)	**
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	0.059 (1.79)	*
			Dist. choice (enrlmt-based) * mostly state control	IV[a]	0.085 (3.04)	***
			Dist. choice (enrlmt-based) * mostly local control	IV[a]	0.099 (3.81)	***
Grosskopf, Hayes, Taylor & Weber (1999b)	Texas, 1988-89, Districts, n=244	Allocative inefficiency, output scores per Dist., gr 5 and 11: M	Switch: Critical HI, dummy variable equals 1 if HI>z,	DEA, boot-strapped LS, Z estimated with ML Adjusts for student ability	MC595: 2.03 (1.09, 2.79)	**
			Switch*HI		MC595: 0.04 (0.03, 0.06)	**
			HI [mm 11-87]		MC595: -0.05 (-0.11, 0.02)	Nsd
			Switch*HI		0.08 (0.03, 0.11)	**
Duncombe, Miner & Ruggiero (1997)	New York State, 1990-91, 585 school districts	Cost-efficiency % per Dist. [78.4, na]	Private school stud. In Dist. [na]	DEA, Tobit	-0.2162 (2.82)	**
			City Dist. [na]		-0.0654 (2.52)	**
			No of all schools [na]		-0.0022 (1.54)	Nsd
			Density of schools [na]		0.0006 (0.05)	Nsd

Table A4

The Effects of Competition on Teacher Quality, on Private School Enrollment, on Wages, on Housing Values

Source	Data	Dependent variable [mean, s.d.]	Independent variable [mean, s.d.]	Estimation method	Coeff. (|t|)	Signif.
		TEACHING QUALITY:				
Borland & Howson (1993)	Ken., 1989-90, n=170	Teacher salaries [na]	HI critical value [na]	Switching regime, 2SLS	-692.6 (2.05)	**
Borland & Howson (1995)	Ken., 1995, n=170	Teacher salaries [na]	HI [na]	OLS	-666.2 (1.92)	nsd
Vedder and Hall (2000)	Ohio BoE, 1996 Census, districts n=606	Average teacher salary in Dist. [35458, na]	Within-state county private school enrlmt [mm 0-45.52]	OLS Adjusting for funding	54.20 (3.47)	***
			Number of public schools districts in a county [7, na]	OLS Adjusting for funding	73.45 (4.20)	***
Hoxby (1994)	N=1093	Public school teacher starting salary [10785, 1142: 1980$]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV FGLS	71.20 (6.39) -0.40 (0.08)	*** nsd
Arum (1996)	States, Census, 1980, n=50	Public school ST ratio [17.9, 2.11]	% private schooling [9.6, 4.79]	OLS[a] OLS[b] OLS[c]	-0.209 (3.37) -0.220 (3.49) -0.175 (2.46)	*** *** **
		Public school ST ratio minus private school ST ratio [1.86, 2.40]		OLS[a] OLS[b] OLS[c]	-0.266 (3.75) -0.357 (4.82) -0.191 (2.85)	*** *** ***
Hoxby (2000a)	CCD, Districts, n=6523	Student–teacher ratio [na]	Enrollment based choice [0.77, 0.24]	OLS IV[a] IV[b] IV[c]	0.375 (1.40) -2.669 (2.46) -2.493 (2.51) -2.448 (1.67)	Nsd ** ** *
			Choice based on Dist. land area	IV[a]	-2.582 (2.30)	**
			Choice based on school enrollment	IV[a]	-3.828 (0.71)	nsd

Hoxby (2000b)	SASS, 1993, CCD, MAs=308	Extra instructional hours []	Index of school choice among public school districts in teacher's MA []	IV, Streams	2.279 (46)	***
			Share of students who attend private school in teacher's MA []	IV, Religious denominations	0.872 (1.36)	nsd
		Extra non-instructional hours []	Index of school choice among public school districts in teacher's MA []	IV, Streams	1.095 (2.16)	**
			Share of students who attend private school in teacher's MA []	IV, Religious denominations	1.122 (1.45)	nsd
		Control teachers have over teaching methods [mm1-6]	Index of school choice among public school districts in teacher's MA []	IV, Streams	0.076 (0.75)	Nsd
			Share of students who attend private school in teacher's MA []	IV, Religious denominations	0.036 (1.16)	nsd
Marlow (2000)	Calif., 1993, Counties *n=54*	TS ratio 4th gr [0.05, 0.006]	HI [0.32, 0.29]	SUR[a]	0.01 (1.81)	*
		TS ratio 4th gr [0.05, 0.006]	HI [0.32, 0.29]	SUR[b]	0.01 (3.09)	***
		TS ratio 8th gr [0.05, 0.006]	HI [0.31, 0.28]	SUR[a]	0.005 (1.64)	nsd
		TS ratio 8th gr [0.05, 0.006]	HI [0.31, 0.28]	SUR[b]	0.01 (3.23)	***
		TS ratio 10th gr [0.05, 0.006]	HI [0.42, 0.27]	SUR[a]	0.004 (1.36)	nsd
		TS ratio 10th gr [0.05, 0.006]	HI [0.42, 0.27]	SUR[b]	0.01 (2.55)	**
PRIVATE SCHOOL ENROLLMENT:						
Smith & Meier (1995)	Florida, panel of districts, 1986-90, *n*=329	% private school enrollment [na]	Lagged public school performance: M [na]	OLS Controls for %Catholic, % black, family income, year fixed effects OLS, controls for per-pupil expenditure	0.004 (0.004)	nsd

Goldhaber (1999)	New York state, panel of districts, 1981-91, n=5580	% private school enrollment [18.32, 16.14]	% of public school students who go on to 4-year college [34.53, 19.98]	OLS, Controls for private school characteristics, urbanicity, ethnicity	-0.300 (1.75)	*
Martin-Vazquez & Seaman (1985)	Census, 1970, SMSA, n=75	Total Elementary private school enrlmt [na]	A: Primary school districts * 10^{-3}		0.324 (1.27)	nsd
			B: Schools per district * 10^{-5}		-0.527 (0.11)	nsd
			A*B interaction		-0.116 (2.61)	**
		Parochial elementary private school enrlmt [na]	A: Primary school districts * 10^{-3}		0.388 (1.56)	nsd
			B: Schools per district * 10^{-5}		0.244 (0.04)	nsd
			A*B interaction		-0.114 (2.64)	***
		Non-parochial elementary private school enrlmt [na]	A: Primary school districts * 10^{-3}		-0.070 (1.25)	nsd
			B: Schools per Dist. * 10^{-5}		-1.258 (1.11)	nsd
			A*B interaction		-0.008 (0.80)	nsd
		Total secondary private school enrlmt [na]	A: Secondary school districts * 10^{-3}		0.065 (0.19)	nsd
			B: Schools per Dist. * 10^{-4}		-0.242 (0.45)	nsd
			A*B interaction		-0.200 (2.04)	**
		Parochial secondary private school enrlmt [na]	A: Secondary school districts * 10^{-3}		0.330 (1.06)	nsd
			B: Schools per Dist. * 10^{-4}		-0.091 (0.03)	nsd
			A*B interaction		-0.173 (2.02)	**
		Non-parochial secondary private school enrlmt [na]	A: Secondary school districts * 10^{-3}		-0.309 (2.53)	**
			B: Schools per Dist. * 10^{-4}		-0.304 (1.53)	nsd
			A*B interaction		-0.051 (1.50)	nsd
Hoxby (2000a)	CCD, Districts, n=6523	Share of students in private school [0.12, 0.06]	Enrollment based choice [0.77, 0.24]	OLS	0.006 (1.00)	Nsd
				IV[a]	-0.042 (2.33)	
				IV[b]	-0.067 (3.05)	**
				IV[c]	-0.067 (2.16)	***
						**
			Choice based on Dist. land area	IV[a]	-0.043 (2.15)	**
			Choice based on school enrollment	IV[a]	-0.180 (1.13)	nsd
		WAGES:				
Jepsen (1999)	Individuals NLS, 1972, n=13653	Log wage 1977 in 1990$ [0.065, 0.44]	Dist. To Cath. School [19.71, 27.41]	OLS	0.0002 (1.00)	Nsd
				IV, Cath. popn density	0.0006 (0.25)	Nsd

			County private schooling [9.26, 5.59]	OLS	0.0000 (0.10)	Nsd
				IV, Cath. popn density	0.0054 (2.57)	**
			MSA private schooling [9.38, 4.98]	OLS	-0.0010 (0.91)	Nsd
				IV, Cath. popn density	0.0037 (1.54)	nsd
Hoxby (1994)	NLSY, 1990, n=10589	Log Hourly wage at 24 [1.96, 0.48; 1990$]	% county secondary school enrollment in Catholic schools [4.47, 5.33]	IV	0.0019 (3.17)	***
				FGLS	0.0002 (1.00)	nsd
Hoxby (2000a)	Census, MAs, n=209, NLSY students, n=5944	Ln income at 32 [9.66, 1.15]	Dist. choice (enrlmt-based) [0.686, 0.271]	OLS	0.055 (1.90)	*
				IV[a]	0.151 (2.10)	**
				IV[c] natural boundaries	0.170 (0.71)	nsd
			Dist. choice (enrlmt-based) * low income family	IV[a]	0.189 (2.01)	**
			Dist. choice (enrlmt-based) * high income family	IV[a]	0.193 (2.12)	**
			Dist. choice (enrlmt-based) * minority status	IV[a]	0.188 (1.92)	*
			Dist. choice (enrlmt-based) * non-minority status	IV[a]	0.187 (2.25)	**
			Dist. choice based on land area [0.761, 0.269]	IV[a]	0.159 (2.18)	**
			Index of choice of schools, based on enrollment [0.974, 0.069]	IV[a]	1.436 (0.61)	nsd
HOUSING VALUES:						
Barrow & Rouse (2000)	Census data, tax data, 1991, n=11827	Change in aggregate house value per pupil [45.03, 113.25]	Change in predicted basic state aid per pupil [1031.4, 1679.4]	IV, split by county HI		
				HI<0.15 [0.22]	49.86 (6.25)	***
				0.15<HI<0.46 [0.32]	-18.20 (8.36)	***
				HI>0.46 [0.46]	-1.23 (11.40)	***
			Change in predicted total state aid per pupil [1057.4, 1732.4]	IV, split by county HI		
				HI<0.15 [0.22]	52.95 (6.19)	***
				0.15<HI<0.46 [0.32]	-17.63 (7.85)	***
				HI>0.46 [0.46]	-1.70 (12.00)	***

Table A5

Abbreviations / Glossary

Label	Meaning
[na]	not reported by authors
[mm]	minimum-maximum
***	significant at 1% level
**	significant at 5% level
*	significant at 10% level
nsd	no statistically significant difference
MC595	Median coefficient, 5th and 95th percentile
R	Subject: Reading
WR	Subject: Writing
M	Subject: Maths
A	Subject: Arts
LG	Subject: Learning
VB	Subject: Verbal
Al	Subject: Algebra
Xi	Subject: Other
gr	School grade
HI	Herfindahl Index
SUR	Seemingly Unrelated Regression
OLS	Ordinary Least Squares
2SLS	Two-stage Least Squares
FGLS	Fixed Effects Generalized Least Squares
IV	Instrumental Variables
FE	Fixed Effects
DEA	Data Envelopment Analysis
a, b, c, d	Vector of control variables: version a, b, c, d
PLOT	Scatterplot of dependent and independent variables
Dist.	District
DES	Department of Education Statistics
NLSY	National Longitudinal Survey of Youth, DES
HSB	High School and Beyond Survey
ITED	Iowa Test of Educational Development
SAT	Scholastic Aptitude Test
TS ratio	Teacher–Student Ratio
ST ratio	Student–Teacher Ratio
DEA	Data Envelopment Analysis
FSL	Free School Lunch

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