

## Trends in School Economic Segregation, 1970 to 2010

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## **Abstract**

Trends in the racial segregation of schools are well documented, but less is known about trends in schools' *economic* segregation. We use multiple data sources to document trends from 1970 to 2010 in between-district *residential* segregation and in both between-district and between-school *enrollment* segregation by income. We find that between-district residential segregation among all families grew from 1970 to 1990 and again from 1990-2010. After 1990, we examine trends by family type and find that between-district residential segregation increased more among families with school-age children than among all families. Since 1990, segregation between students who are eligible and ineligible for free lunch increased both between districts and between schools. Rising economic segregation at both the district and school level has serious implications for inequality in students' access to resources and academic achievement.

*Keywords:* school segregation, economic segregation, schools, school districts, social stratification

## Introduction

Trends in *racial* segregation of schools and school districts have been well documented over the past half century, but we know far less about trends in *economic* segregation (Reardon & Owens, 2014). We know that residential segregation of census tracts by income has increased sharply since the 1970s (Jargowsky, 1996; Reardon & Bischoff, 2011a, 2011b; Watson, 2009). This leads to the hypothesis that economic segregation between schools and school districts may also have risen, but we do not know to what extent this trend among census tracts has affected schools and school districts.

Residential segregation at the tract level and pupil segregation at the school level are obviously related, but not in any simple or predictable way. Standard measures of residential segregation at the tract level include many childless households, and in some tracts the incomes of childless households are quite different from those of households with school-age children. In addition, census tract boundaries seldom correspond perfectly with school attendance zone boundaries, and even when they do, parents do not always send their children to the nearest public school. Some children attend private schools, charter schools, magnet schools, or open enrollment schools that draw from multiple neighborhoods. All these factors work to decouple patterns of residential segregation from patterns of school segregation. On the other hand, even when parents have a wide range of choice about where to send their child, those choosing an elementary school usually put a lot of weight on proximity (Hastings, Kane, & Staiger, 2005). Furthermore, when schools of choice are oversubscribed, proximity is often a key factor in determining which applicants will be admitted (Hastings et al., 2005). How closely trends in the economic segregation of schools match the trends in the economic segregation of tracts is therefore an open question.

Parents make choices about where to live and where to enroll their children in school based on the characteristics of both school districts and individual schools. The level of economic segregation between school districts may be an unreliable guide to trends in economic segregation

among schools because within-district student assignment policies and parental choices may strongly influence within-district enrollment patterns. We therefore examine three distinct kinds of segregation. We start with *between-district residential segregation*, which measures the degree to which all families, regardless of whether they have children enrolled in school, are segregated by income between school districts. Then we turn to *between-district student enrollment segregation* to explore the degree to which families with children enrolled in public school are segregated by income between different school districts. Finally, we examine *between-school student enrollment segregation*, which tells us the degree to which enrolled students are segregated by income between schools. We examine each kind of segregation within metropolitan areas; in the case of between-school enrollment segregation, we also examine segregation within school districts.

Understanding trends in each type of economic segregation is important because the economic segregation of schools and districts may have implications for resource inequality and student achievement. Recent research documents a growing achievement gap in the U.S. between children in high- and low-income families, a trend that contrasts with the decline of racial achievement gaps over the past 50 years (Reardon, 2011b). Economic segregation could contribute to the growing economic achievement gap in several ways. First, school districts rely partly on local funding linked to the economic characteristics of residents, so if between-district economic segregation rises, resources will become more unequal unless state or federal aid formulas become more redistributive. Between-district residential segregation is relevant here because the economic resources and political actions of families can lead to resource inequalities regardless of whether their children attend public school. Second, between-district and between-school enrollment segregation shape a school's economic composition, which can affect student achievement through peer influences, parent involvement, school organization, and teachers' choices about where to work (or not work) (Schwartz, 2010).

In this article, we use multiple data sources to document trends in residential segregation

between districts by income from 1970 to 2010 and student enrollment segregation between districts and between schools from 1990 to 2010. We measure income segregation between districts in two ways. One relies on family income as measured in the Census, where income is reported in 15 to 25 ordered categories. The other relies on free lunch eligibility (FLE) counts, for which income is measured dichotomously. We measure segregation between schools using only the school-level FLE counts, as more detailed information on family income is not available at the school level. Overall, we find that between-district *residential segregation* was considerably higher in 2010 than in 1970, and between-district and between-school *enrollment segregation* is moderately higher in 2010 than in 1990.

### **Implications of Economic Segregation**

School economic segregation may lead to disparities in school resources and contexts, which in turn may have consequences for academic achievement. Therefore, documenting trends in school economic segregation is an important part of identifying potential causes of educational inequalities. First, between-district residential segregation may lead to inequalities in the financial resources available to school districts. A substantial amount of school funding is raised through local tax revenue, often through property taxes (Baker & Corcoran, 2012). Income segregation implies substantial variation among school districts in their level of school funding. In many states, these inequities are partially or wholly offset by state and federal funding, but there are still many states where funding is linked to local residents' income and property values (Baker & Corcoran, 2012). Schools that serve low-income populations do tend to have fewer instructional resources, less competitive curriculums, and teachers with fewer formal qualifications (Orfield & Eaton, 1996; Phillips & Chin, 2004), and past research has shown that standardized test scores are more equal in states that rely less on local taxes for school funding, suggesting that disparate spending can influence student achievement (Card & Payne, 2002; Downes & Figlio, 1997). Further, even if

funding formulas are equalized, economic segregation between districts may produce high-income districts where residents, particularly parents, vote to spend more on schooling. In addition, poorer districts may need more financial resources than richer districts to provide equal opportunities for educational success, such as a safe environment, schools in good physical condition, and high-quality teachers, who may require higher salaries to work in poor districts seen as undesirable (Boyd, Lankford, Loeb, & Wyckoff, 2013; Corcoran, Evans, Godwin, Murray, & Schwab, 2004). Therefore, residential segregation between districts can lead to inequalities in resources and, in turn, academic achievement.

Enrollment segregation between both schools and districts affects the socioeconomic composition of the student body. Segregation between districts determines how much school integration can occur—no amount of within-district re-assignment of students can overcome high levels of segregation between districts. Segregation between schools determines who students' peers will be. Student body composition may affect student achievement because it can influence teacher quality, school environment, parent involvement, student-teacher interactions, or peer interactions (Kahlenberg, 2002; Rumberger & Palardy, 2005; Schwartz, 2010). Some correlational studies have suggested that mean student SES impacts student achievement (Gamoran, 1996; Mayer, 1991; Rumberger & Palardy, 2005), though others have not found much relationship between the two (Carbonaro & Gamoran, 2002; Jencks & Mayer, 1990). Correlational studies face methodological challenges in assessing causal impacts of student body composition on student achievement. Schwartz (2010) takes advantage of random student assignment in Montgomery County to compare the performance of students living in public housing that attended the district's most versus least advantaged schools. She finds that students from public housing in low-poverty elementary schools had significantly higher scores in math and reading than equally poor students assigned to high-poverty schools, and these positive impacts accumulate over time.

## **Trends in Segregation between Schools and Districts**

A large body of social science research has documented trends in racial segregation between schools and districts since *Brown v. Board of Education* in 1954 (see Reardon & Owens 2014 for a review). Overall, school racial segregation declined through 1980, with most of the change occurring in the late 1960s and early 1970s. Since the mid-1980s, minority students' exposure to other minority students has risen (Orfield & Lee, 2007; Orfield, 2001). However, this is due mainly to the decline in white student enrollment and the growth in Hispanic student enrollment. Net of changes in racial composition, the sorting of students between schools by race changed little in the 1990s and declined slightly in the 2000s (Logan, 2004; Stroub & Richards, 2013). Black-white segregation between districts increased from the early 1970s through the 1990s but has declined slightly since 2000 (Coleman, Kelly, & Moore, 1975; Rivkin, 1994; Stroub & Richards, 2013).

We know relatively little about economic segregation between schools and districts, but several related studies provide suggestive evidence. Corcoran and Evans (2010) examine income inequality within and between school districts within metropolitan areas from 1970 to 2000 and find that the share of income inequality attributable to between-district inequality (which is one measure of income segregation) grew by 40% from 1970 to 2000. There is also extensive evidence on the rise in income segregation between neighborhoods since 1970 (Bischoff & Reardon, 2014; Jargowsky, 1996; Reardon & Bischoff, 2011b; Swanstrom, Casey, Flack, & Dreier, 2004; Watson, 2009). In particular, Reardon and Bischoff (2011a) find that much of the increase in income segregation is due to an increase in segregation at a large geographic scale. To the extent that this large-scale residential segregation trend is mirrored in school segregation patterns, one might expect that between-district residential segregation has also increased.

With regard to enrollment segregation by income between schools, we likewise have relatively little clear evidence. One exception is Rusk (2002), who uses data on the enrollments of

students in all public elementary schools in the U.S. from 1989 to 1999 to explore trends in economic segregation. Using dissimilarity indices that compare how FLE and non-FLE students are distributed among all elementary schools, he finds that economic segregation between these two groups increased on average among the 65,000 elementary schools nationwide from 1989 to 1999. Among elementary schools in the 100 largest metropolitan areas, economic segregation rose in 53 metros, was stable in 15, declined in 13, and could not be calculated in 19. The mean change in the dissimilarity index for the 100 largest metropolitan areas was 2.2 points (on a 0 to 100 scale) during the 1990s. Although Rusk's results are a useful starting place, his analysis does not include data past 1999, and many schools (including those in several of the largest school districts in the U.S.) are missing FLE counts in the early 1990s, making the overall trend somewhat uncertain. Moreover, his measure of economic segregation is based only on segregation between FLE and non-FLE students, rather than on segregation across the full income distribution.

While few studies examine segregation by income between schools, a large body of research documents segregation by income between neighborhoods (Bischoff & Reardon, 2014; Jargowsky, 1996; Reardon & Bischoff, 2011b; Swanstrom et al., 2004; Watson, 2009). However, school choice policies, magnet schools, and charter schools all became more common after 1970, so school segregation may not have moved in tandem with residential segregation. Saporito and Sohoni (2007) studied 21 of the 22 largest U.S. school districts in 2000 and found that school poverty rates were typically *higher* than the poverty rate among all children in a school's catchment area, particularly when the catchment area was predominantly non-white. This suggests that non-poor families in high-poverty catchment areas often choose private, charter, or magnet schools, leaving the most disadvantaged children in local public schools with few middle-class peers (Saporito 2003). Beginning in the 1990s, some school districts began to shift school assignment policies from focusing on race to focusing on family income. Kahlenberg (2002, 2006a) found that the number of students in districts with attendance policies that consider family socioeconomic



status (SES) when assigning students grew from 1999 to 2006. Reardon and Rhodes (2011) also find an increasing number of students in districts with SES-based student assignment plans, but they note that the number of districts with such plans is small (roughly 70 school districts, enrolling 1.6 million students, or roughly 3% of all public school students in the U.S.).

Evidence on whether school choice policies have reduced SES segregation between schools is mixed. Examining non-SES-based school choice policies affecting elementary and middle school students in Durham, NC, Bifulco, Ladd, and Ross (2009) find that students are *more* segregated by race and parental education under school choice policies than they would be if they went to their neighborhood school. Archibald (2004) finds no difference in school economic segregation between districts with and without magnet-school choice policies. Reardon and Rhodes (2011) find no evidence that economic segregation levels change after districts adopt SES-based choice plans, a finding they attribute to the relatively toothless nature of the SES components of these plans. However, Kahlenberg (2006a) concludes that socioeconomic integration plans in Cambridge, MA, Wake County, NC, San Francisco, and La Crosse, WI, reduced socioeconomic segregation.

In sum, past research provides little clear evidence on trends in economic segregation between schools or districts. Indeed, the best evidence on segregation by income focuses almost exclusively on residential segregation between census tracts. There are, however, many reasons to suspect that trends in school and district enrollment segregation by income may not mirror trends in neighborhood segregation by income. In this article, we document the trends in school and school district economic segregation from 1970 to 2010. Because better data are available from 1990 onward, we focus more on the 1990-2010 trends than on the 1970-1990 trends.

## **Data**

To investigate trends in school economic segregation over time, we would ideally like data on the exact family income of all students in all schools and over many years. With such data, we

could describe any changes in between-school and between-district segregation in detail. However, such data are not readily available. Instead we use multiple data sources to report trends in school economic segregation measured in several ways. Each of these data sources provides counts of families or children in income or poverty categories at the school or district level. We then calculate between-district and between-school segregation within metropolitan areas or districts (in the case of between-school segregation) as described below.

### Census Data

We start by considering segregation of all families between school districts by income. We focus on family income rather than household income as families are the most relevant for school segregation. Single-person households are thus excluded from analyses. Since 1970, the Census Bureau has provided tabulations of the number of families by income level living in each school district in the U.S. These tabulations come from several different sources. The School District Geographic Reference File, 1969-1970 (U.S. Department of Commerce, 1970), distributed by ICPSR, provides a link between 1969-1970 school district boundaries and 1970 census tract and enumeration district data (Adams, 2007).<sup>1</sup> Family income from the 1970 Census is available in 15 categories. For 1980, the Census of Population and Housing, 1980: Summary Tape File 3F, School Districts (U.S. Department of Commerce, 1983) provides family income in 17 categories for all families within each school district. From 1990 onward, the School District Demographics System (SDDS), produced by the National Center for Education Statistics (NCES), provides estimates of the number of families in each of 16 income categories (25 categories in 1990) living within each school district's boundaries. The SDDS data come from the School District Special Tabulation

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<sup>1</sup> The 1970 School District Geographic Reference File provides the percent of the tract or enumeration district (ED) population residing within district boundaries. Seventy-six percent of tracts or EDs exist entirely within one district. For the remaining 24%, we multiply the income counts for the tract/ED by the proportion population in the district to aggregate to the district level.

Census files from the 1990 and 2000 Census and the 2006-10 American Community Survey (ACS) estimates (for parsimony, we describe the 2006-10 ACS as referring to the year 2008 throughout the rest of this article). We use these data to estimate trends in between-district residential segregation for all families within metropolitan areas from 1970 to 2008.

The SDDS also provides income tabulations for two other relevant populations: (1) all families with school-age children (age 3 to 19 without a high school diploma) living within district boundaries; and (2) families living within district boundaries who report that one or more of their school-age children attends public school. We calculate between-district *residential* segregation of families with school-age children living in U.S. elementary or unified school districts in 1990, 2000 and 2008.<sup>2</sup> These data include not only students enrolled in local public schools, but also those enrolled in private schools or who are home-schooled. We calculate between-district *enrollment* segregation within metropolitan areas from data on the income of families with at least one child enrolled in public school in U.S. elementary or unified school districts in 1990, 2000, and 2008. (See Appendix A for a list of missing counties in 1990.) In sum, we measure *between-district residential segregation of all families* from 1970 to 2008; *between-district residential segregation of families with school-age children* from 1990 to 2008; and *between-district enrollment segregation of families with children enrolled in public school* from 1990 to 2008.<sup>3</sup>

## Common Core of Data

We estimate between-school and between-district enrollment segregation of students

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<sup>2</sup> Most districts in the U.S. are unified—they include grades K-12—so each residential location falls within one school district. However, in some places, there are separate elementary and secondary districts, so a family can live in both an elementary and a secondary district. In those places, we use the elementary district boundaries so that each household is in exactly one district (either a unified or an elementary district) in our analyses. This avoids double counting households in non-unified districts.

<sup>3</sup> Note that the SDDS data are at the family level, not the child level, as child-level data are not available after 2000. Segregation estimates in 1990 and 2000 based on child-level data are very similar to those based on family-level data.

within metropolitan areas and between-school enrollment segregation of students within districts using the Common Core of Data (CCD), a publicly available dataset compiled annually since 1987-88 by the NCES. The CCD contains school- and district-level data for all public schools in the U.S., including enrollment counts by grade, race and ethnicity, and free and reduced-price lunch eligibility. Families with incomes less than 130% of the poverty line are eligible for free meals while families with incomes between 130% and 185% of the poverty line are eligible for reduced-price meals. Prior to 1998, the CCD includes school-level counts only of FLE students; from 1998 onward, the CCD includes counts of both free and reduced-price lunch eligible students. For consistency, we calculate segregation between FLE students and all others in all years. Because the CCD does not include grade-specific counts of FLE students within each school, we estimate FLE counts for each grade by multiplying the enrollment count for the grade by the school-wide proportion of FLE students when reporting results by grade.

Not all states reported FLE counts by school for each year of the CCD, particularly in the earlier years of the survey. We exclude FLE counts from 1987 to 1990 when the proportion of missing data was very high in many states. Furthermore, we compute segregation within metros and districts only when at least 80 percent of students are in schools that report FLE data. By 1991 two-thirds of metropolitan areas and 75 percent of the 100 largest districts meet this requirement. By 2010 nearly all metros and the 100 largest districts are included. We compute average trends in FLE enrollment segregation between schools and between districts within metropolitan areas and trends in FLE enrollment segregation between schools within districts from 1991 to 2010 using either metropolitan area or district fixed effects to account for the unbalanced data panel.

The CCD data have two important limitations. First, they do not include information on the full income distribution within a given school. As a result, the CCD measures of economic segregation are only sensitive to income segregation between FLE and non-FLE students. This corresponds roughly to segregation of the bottom 25% of the income distribution from the top

75%. If segregation is changing elsewhere in the income distribution (if, for example, children from affluent families are becoming increasingly segregated from middle-income families), our CCD-based segregation measures will not capture the change.

A second limitation of the CCD data is that reported FLE counts are an imperfect proxy for true student eligibility counts (Harwell & LeBeau, 2010). Some eligible students do not enroll in the free lunch program, and some ineligible students are enrolled incorrectly. As a result, FLE counts do not always accurately capture the true eligibility rates within school. Appendix B presents some evidence of the mismatch between CCD FLE counts and true eligibility rates. Importantly, the CCD appears to inflate counts of FLE students more in districts where there are more “true” FLE students. We use the CCD data to calculate between-school and between-district enrollment segregation because it provides the only school-level data on students’ income over time, but these results should still be interpreted with caution.

### **Measuring Segregation**

Income segregation—the extent to which high- and low-income students attend separate schools or live in separate districts—can be measured in many ways (Reardon & Bischoff, 2011b; Reardon & Firebaugh, 2002; Reardon, 2009, 2011a). We use the rank-order information theory index to measure segregation across the full income distribution using SDDS data. We use the binary information theory index to measure segregation between FLE and non-FLE students using the CCD data. Both indices are denoted as  $H$ . In both cases,  $H$  compares the variation in family incomes within school districts (or schools) to the variation in family incomes within their metropolitan area (or school district, in the case of between-school segregation). The binary  $H$  measures segregation between children from families below and above a single FLE income threshold, while the rank-order  $H$  is a weighted average of the binary  $H$  computed at every threshold between the multiple income categories (Reardon, 2011a).  $H$  does not measure exposure.

Rather, it measures non-random sorting of families by income across units like school districts or schools.

Because the rank-order  $H$  index relies only on information about families' ranks in the income distribution rather than their actual income, it is less sensitive to inflation and to changes in the shape of the income distribution than other segregation indices. As a result,  $H$  does not confound changes in income inequality with changes in income segregation (Reardon & Bischoff, 2011b; Reardon, 2011a). Reardon (2011a) also shows  $H$  is not very sensitive to the number or location of thresholds used to define income categories so long as there are more than a modest number of categories that capture the underlying distribution well. This feature makes  $H$  particularly useful for comparing income segregation across time.<sup>4</sup> The binary  $H$ , however, may be sensitive to the proportion of students meeting the FLE income threshold, so changes in segregation between FLE and non-FLE students may be confounded by changes in the proportion of FLE students.

In theory,  $H$  can range from 0 (no segregation) to 1 (total segregation). In a hypothetical metropolitan area where all school districts had identical family income distributions (and were therefore identical to the overall metropolitan area distribution), the index would equal 0, indicating no segregation by income. In contrast, in a metropolitan area where all families in a school district always had the same income,  $H$  would equal 1. Although the magnitude of  $H$  does not have a particularly intuitive meaning, it is analogous to Jargowsky's (1996) Neighborhood Sorting Index (NSI) in that it can be interpreted as measuring the proportion of variation in income that lies between, rather than within, units like schools or school districts. One main difference is that  $H$  is based on income *ranks*, while the NSI is based on actual income (in dollars). As a result, the NSI is sensitive to changes in the shape of the income distribution, while  $H$  is not. A second difference is

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<sup>4</sup> We describe the technical details of calculating the rank-order information theory income segregation index in Appendix A.

that  $H$  measures income variation using a form of the entropy index, while the NSI uses the standard deviation of income.

We present trends in  $H$  for the 100 largest metropolitan areas and for the 100 largest districts by population. Because the increase in residential segregation since 1970 has been greatest in large metropolitan areas (Reardon and Bischoff 2011a), we examine changes in  $H$  within the 100 largest metropolitan areas based on OMB 2003 MSA definitions and 2009 populations. (Five of the 100 largest metropolitan areas include only 1 school district, so the analysis sample for between-district segregation includes only 95 metropolitan areas). We also calculated trends in  $H$  within states, and these trends are largely similar to those within metropolitan areas. Because metropolitan areas represent the set of options available to families when they are making residential choices better than states do, we present the metropolitan area results. Throughout the results, we describe the magnitude of the change in  $H$  in terms of percent changes, standard deviation changes, and in comparison to racial segregation.

## Results

### Trends in Between-District Residential Segregation by Income

The SDDS data allow us to calculate residential segregation between districts of all families. Average between-district residential segregation levels ( $H$ ) from 1970 to 2008 across metropolitan areas (not weighted by population) are presented in Figure 1 (solid black line) and in Table 1. Among all families, between-district income segregation rose from  $H = 0.032$  in 1970 to  $H = 0.055$  in 2008.

[Figure 1 about here]

[Table 1 about here]

It is useful to compare the level of income segregation to levels of racial segregation. First,

however, note that measurement error accounts for roughly 10-30% of the variance in self-reported annual income, implying that a more accurate estimate of income segregation in 2008 would be roughly 0.070.<sup>5</sup> In a separate analysis (not shown) we computed *racial* segregation of all family households between districts using binary  $H$  in 2008. Black-white segregation was 0.19, and Hispanic-white segregation was 0.12. Thus, between-district income segregation appears to be roughly 40-60% as large as black- and Hispanic-white racial segregation.<sup>6</sup>

What are the trends in income segregation between districts? Average between-district residential segregation in the 100 largest metropolitan areas was 0.032 in 1970 and 0.055 in 2008, a 70% increase over four decades. The standard deviation of  $H$  was 0.019 in 1970, so the 0.023 change from 1970 to 2008 represents a 1.2 standard deviation increase in  $H$ . The largest increases in residential income segregation between districts occur during the 1970s and 1980s, consistent with trends in residential segregation between neighborhoods, which also increased most during this period (Reardon & Bischoff, 2011b; Watson, 2009). After 1990, between-district residential segregation among all families increased by 0.005, an increase of 10% of the 1990 level and 17% of the 1990 standard deviation, as shown in Table 2.

[Table 2 about here]

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<sup>5</sup> To see this, note that measures of segregation like  $H$  can be thought of as measures of the proportion of variation in income that lies between districts. However, because income is measured noisily, measures like  $H$  will be attenuated. The attenuation will be proportional to the reliability of the income measure. Estimates of the reliability of self-reported annual income as a measure of true annual income range from 0.7 to 0.9; estimates of its reliability as a measure of permanent income are roughly 0.5 (Marquis, Marquis, & Polich, 1986; Mazumder, 2001). If we take a value of 0.8 as the reliability of income, then we can get a corrected estimate of income segregation in 2008 as  $H \approx \frac{0.055}{0.8} \approx 0.07$  (a reliability of 0.5 would imply  $H \approx \frac{0.055}{0.5} \approx 0.11$ ). Using a different method, (Dickens, 2003) found that estimates of income segregation should be inflated by 15-30% to adjust for measurement error, an amount that implies a reliability of 0.75-0.85.

<sup>6</sup> We estimate racial segregation using 2006-10 SDDS counts of the race of the householder among family households for districts in the 100 largest metropolitan areas. The SDDS does not provide all Census tabulations at the district level, so we are limited to estimating segregation between districts between non-Hispanic whites and Hispanics and between non-Hispanic whites and all blacks (Hispanic ethnicity is not provided for blacks).



Next, we examine between-district residential segregation for families with school-age children, which is available from 1990 to 2008. The trend in average segregation across the 100 largest metropolitan areas is shown in both Figure 1 and Table 1 (row 2). These data include families whose children attend school in another district or in private schools. (About 10% of students attend private schools nationally and only about 1% of public school students attend school in a district where they do not reside (National Center for Education Statistics, 2008)). Figure 1 (solid gray line) shows that average between-district residential economic segregation of families with school-age children rose from 0.068 in 1990 to 0.082 in 2008, a 21% change and an increase of about 1/3 of the 1990 standard deviation (Table 2). Between-district residential segregation by income is higher and increased more sharply for families with school-age children than for all families after 1990, particularly after 2000. While school district boundaries have always been more important in shaping residential decisions for families with children than for other families, school district boundaries have become increasingly important during the past 20 years for families with children.

Another way to think about the level of economic segregation is to compare the segregation of the poor to the non-poor (based on FLE status), which also allows us to compare between-district segregation to between-school segregation, discussed below. We estimated the proportion of families with incomes below 130% of the family-size specific poverty threshold using March Current Population Survey data in 1970, 1980, 1990, 2000, and 2008.<sup>7</sup> About 20% of families were free lunch eligible in each year.<sup>8</sup> We can calculate  $H$  at any point in the income distribution by

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<sup>7</sup> Analyses based on SDDS are at the family-level rather than child-level. The free lunch eligibility rate at the family level is lower than at the child level reported in Appendix B. Because of this, the FLE analyses are not strictly comparable between the CCD and SDDS. We use the 2008 CPS because 2008 is the 2006-2010 midpoint.

<sup>8</sup> The FLE rate estimates are based on national eligibility rates. The proportion of children eligible for free lunch varies across metros, of course, so our metro FLE segregation trend estimates are necessarily somewhat imprecise.

fitting a polynomial through the estimates of  $H$  at each income category threshold (see (Reardon, 2011a) for details). Therefore, we examine  $H$  at the percentile in the income distribution corresponding to free lunch eligibility in each year. Figure 1 (dashed black line) and Table 1 (row 3) present the trend in average levels of between-district residential segregation between FLE and non-FLE eligible families. Segregation of FLE families from non-FLE families rises slightly more than segregation using the full distribution of income between 1970 and 1990 (74 versus 56%), but both measures increase by 9 to 10% between 1990 and 2008. Among families with school-age children, however, segregation between districts rises 21% using the full income distribution, compared to only 9% when we measure segregation of FLE from non-FLE families (Table 2). From 1990 to 2008, absolute segregation based on the full income distribution increased more than twice as much as absolute segregation based on FLE status (0.014 versus 0.006) and by nearly three times as much compared to the 1990 standard deviation (0.34 SDs versus 0.13 SDs). This difference suggests that segregation of affluent families with school-age children from other families rose more between 1990 and 2008 than segregation of poor families with school-age children from other families.

To summarize, we find that residential economic segregation between school districts has increased since 1990 among all families but particularly among families with school-age children. The increase in  $H$  among families with school-age children was about twice as large, in percent and SD terms, as the change among all families. For all families and for those with school-age children, segregation based on the full income distribution increased much more than segregation between poor and non-poor families.

#### Trends in Between-District Enrollment Segregation by Income

We now turn to between-district segregation by income of families with children enrolled in public school. Figure 2 (solid line) and Table 1 (row 5) show that between-district enrollment

segregation based on the full income distribution increased, on average, from 0.076 in 1990 to 0.089 in 2008, an increase of about 17% of the 1990 level and 28% of the 1990 standard deviation (Table 2). The increases were statistically significant in both the 1990s and 2000s.

[Figure 2 about here]

Note also that, comparing Figures 1 and 2, average between-district enrollment segregation was slightly larger than between-district residential segregation for families with school-age children in each year. This may be due to differential patterns of private school enrollment. If higher-income families in lower-income districts disproportionately enroll their children in private schools, this will elevate enrollment segregation levels above residential segregation levels. Such a pattern is consistent with the enrollment patterns within school attendance zones evident in Saporito and Sohoni (2007).

As described above, calculating  $H$  using SDDS data allows us to explore how segregation at different points in the income distribution changed over time. Figure 3 presents estimated income segregation in the 100 largest metropolitan areas from 1990 to 2008, showing average segregation at each percentile in the income distribution (based on a 4<sup>th</sup>-order polynomial; see (Reardon, 2011a) for details). The x-axis indexes percentiles of the income distribution  $p$  while the y-axis presents average between-district enrollment segregation  $H$ . The value of the line  $H$  at each percentile  $p$  in each year indicates the average segregation level across the 100 largest metropolitan areas of families with incomes below the  $p$ th percentile from those with incomes above the  $p$ th percentile. Distances between the lines indicates how segregation at that value of  $p$  changed over time.

Figure 3 shows that between-district school enrollment segregation of public school families declined in the bottom quintile of the income distribution from 1990 to 2008. This contrasts with trends in residential neighborhood segregation, as Reardon and Bischoff (2011a) found that residential segregation of those in the bottom 10 percent of the income distribution

increased between neighborhoods from 1990 to 2005-09. This suggests that within-, rather than between-, school district residential segregation of the poorest families from all others has increased since 1990. In contrast, between-district segregation has increased since 1990 among public school families with incomes above approximately the 40<sup>th</sup> to 90<sup>th</sup> percentiles. This suggests that segregation between middle- and upper-middle class families increased. The segregation of very affluent students (those in the top 10% of the income distribution) from all others across school districts changed little in the 1990s, but increased sharply in the 2000s, suggesting that affluent families are increasingly isolating themselves not only in terms of neighborhood residence, as Reardon and Bischoff (2011b) find, but also in terms of the school districts in which they enroll their children. Figure 3 also includes black dots at the income percentiles corresponding to the FLE cutoff in each year. As shown in Figure 2, approximate FLE-non-FLE segregation (based on the SDDS data) changed little during the 1990s but rose from 2000 to 2008.

[Figure 3 about here]

To further explore FLE-non-FLE enrollment segregation between districts, we used SDDS data to estimate between-district enrollment segregation between FLE and non-FLE public school families and CCD data to estimate between-district enrollment segregation between FLE and non-FLE public school students. We follow the procedure describe above to estimate the proportion of public school families eligible for FLE in each year. Figure 2 (dashed line) shows that between-district enrollment segregation between FLE and non-FLE families with children enrolled in public schools increased, but the change was significant only during the 2000s (Table 1, row 6). We use CCD data to estimate between-district FLE-non-FLE segregation of students enrolled in public school. Table 1 (row 7) shows that between-district FLE-non-FLE enrollment segregation based on CCD data is about twice as large as the SDDS estimate. Further, segregation increased in the 1990s and declined slightly in the 2000s among students in the CCD data, in contrast to the trends among families in the SDDS data. Several factors explain these differences. First, as described above, the

CCD FLE counts may inflate the number of students truly eligible for the free lunch program. Second, the SDDS results describe segregation among families, while the CCD results describe segregation among students.<sup>9</sup> Third, the FLE classification in the SDDS data is an approximation based on the national proportion of families with incomes below 130% of the poverty line. We conclude that, based on both datasets, between-district enrollment segregation of FLE and non-FLE students is higher in 2008 than in 1990—by about 8% of the 1990 level and 14% of the 1990 standard deviation based on CCD data and by about 4% of the 1990 level and 6% of the 1990 standard deviation based on SDDS data. To provide a sense of the magnitude of the segregation levels, we compare them to between-district racial segregation levels computed from CCD data. Between-district enrollment segregation between FLE and non-FLE students is about 40% lower than black-white and roughly the same size as Hispanic-white between-district enrollment segregation in the 100 largest metropolitan areas.

We conclude that public school families became more segregated by income between districts from 1990 to 2010. Rising enrollment segregation between districts is not driven by increasing segregation of the poorest families from all others but by upper-middle class families and, in the 2000s, affluent families becoming more segregated from other families. While families with incomes in the bottom 20% of the income distribution have become less segregated from families with incomes above that threshold, the increases in segregation among the middle and upper classes suggests that integration likely occurred among poor and working class, rather than higher-income, families.

### Trends in Between-School Enrollment Segregation by Income

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<sup>9</sup> The SDDS does provide student-level data in 1990 and 2000, and these estimates of FLE-non-FLE segregation are slightly higher than the SDDS estimates of FLE family segregation, but still lower than CCD estimates of FLE student segregation.

Finally, we turn to the economic segregation of students between schools within metropolitan areas and within districts. The CCD data allow us to explore how segregated poor students are from non-poor students between public schools, relying on FLE as our indicator of poverty. These estimates therefore tell us how segregated students from families with incomes below 130% of the poverty line are from all other students. Figure 4 displays the change in average  $H$  measuring enrollment segregation between schools within the 100 largest metropolitan areas from 1991 through 2010. The estimates are based on models that include metropolitan area fixed effects and average trends in  $H$  across grades to account for missing data in some years.<sup>10</sup> We show a break in the trend line in 1998 because there was a change in the way FLE status was reported in the CCD in 1998 (though the reporting change appears to have had no significant effect on the magnitude of computed segregation).<sup>11</sup>

[Figure 4 about here]

Enrollment segregation between the poor or near poor and more affluent students increased by about 10% of the 1990 level and 26% of the 1990 standard deviation during the 1990s but was flat in the 2000s (Table 1, row 8; Table 2). The 1991 to 2000 change in  $H$  was about 0.024 for schools on a 0 to 1 scale, comparable to Rusk's (2002) finding of a 2 point increase on the index of dissimilarity during the 1990s. Just as in the comparison of between-district income and racial segregation, between-school enrollment segregation between FLE and non-FLE students in the 100 largest metropolitan areas is about one-third smaller than black-white enrollment

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<sup>10</sup> The data include one observation of  $H$  for each metro-by-year-by-grade combination. Figure 4 plots the vector  $\Delta_t$  from the model

$$H_{mgt} = \Gamma_g + \Lambda_m + \Delta_t + e_{mgt},$$

where  $\Gamma_g$  is a vector of grade fixed effects,  $\Lambda_m$  is a vector of metropolitan fixed effects, and  $\Delta_t$  is a vector of year fixed effects. Standard errors are clustered at the metropolitan level.

<sup>11</sup> CCD began asking schools to report both free and reduced-price lunch eligible students in 1998. We consider the pre- and post-1998 data separately in case schools erroneously reported both free and reduced-price lunch eligible students prior to 1998 or conflated free versus reduced-price lunch eligible students after 1998.

segregation and about equal to Hispanic-white enrollment segregation between schools, based on our calculations from CCD data.

Segregation among schools within most metropolitan areas occurs because of segregation both between and within school districts. Our segregation measure  $H$  can be decomposed into between- and within-district components by comparing the magnitude of between-district segregation and between-school segregation within the 100 largest metropolitan areas. As Table 1 (rows 7 and 8) shows, from 1991-2010, average between-district FLE-non-FLE segregation of students was roughly 0.15-0.17, while average between-school segregation was roughly 0.24-0.26. Between-district enrollment segregation thus accounts for almost two-thirds of total segregation by FLE status between schools in these metropolitan areas. Segregation between districts also accounts for about two-thirds of total racial segregation between schools (Stroub & Richards, 2013).

We also examined between-school enrollment segregation trends from 1991 to 2010 within the nation's 100 largest school districts, rather than metropolitan areas. Figure 5 shows these results (based on district fixed effects models analogous to those above). Here we find an increase in economic segregation between schools during both the 1990s and 2000s, with a sharp rise in segregation from 2008 to 2010. This rise may have been partly due to the economic recession that began 2008, perhaps because the middle-class families who fell into poverty during the recession were disproportionately located in schools enrolling more poor students, or perhaps because more children eligible for free lunch enrolled in the program during the recession. The trend is slightly steeper in grades K-5 (not shown). The cumulative change in the  $H$  index during the 1990s and 2000s is nearly 5 points (and a roughly 30% increase), a larger increase than that of school segregation within metropolitan areas.

[Figure 5 about here]

Our segregation index measures how evenly poor and non-poor students are distributed

between schools. We also calculated an index of poor (FLE) students' exposure to other poor students, which can be interpreted as the average proportion of FLE students in the average FLE student's school, and exposure of non-poor students to poor students, or the average proportion FLE students in a non-FLE student's school. Figure 6 presents these results as well as the average proportion of poor students in a school.

[Figure 6 about here]

Figure 6 shows that exposure to FLE students increased from 1991 to 2010, as did the proportion of FLE students in the population. Some of the increase in the proportion of poor students is due to a greater number of eligible (and perhaps ineligible) students enrolling in the free lunch program rather than real increases in the number of poor students (see Appendix B). Combined with the previous results for *H*, these findings suggest that, while sorting of FLE and non-FLE students between schools changed little (except in large districts), the average student—in particular, the average poor student—experienced a much poorer school over time. To the extent that segregation affects students through the concentration of poverty in a school, as Schwartz (2010) finds, income segregation may have changed in detrimental ways.

Given the data issues we note, we are cautious in interpreting the CCD results, but they suggest that FLE students became more segregated from non-FLE students between schools, particularly in the 1990s and within large school districts.

## **Discussion**

Economic segregation between schools and school districts has increased over the past several decades. First, residential income segregation of all families between school districts rose 56% from 1970 to 1990, nearly one standard deviation, with much of that increase occurring during the 1980s. Between-district residential income segregation of all families increased by 10%, less than 1/5 standard deviation, from 1990 to 2008. The change in the 2000s was only borderline



significant and slightly lower than the 1990s increase, which is somewhat at odds with the trends in between-*neighborhood* residential segregation by income, which changed little in the 1990s and increased *more* in the 2000s. Increasing residential segregation between neighborhoods in the 2000s may reflect more micro processes that sort families by income into different neighborhoods within the same school district.

Second, after 1990, we can distinguish segregation among all families from segregation among families with school-age children. Between-district residential segregation of families with school-age children increased from 1990 to 2008 by about 20%, or 1/3 standard deviations, with significant increases in both the 1990s and 2000s. The increase in segregation among families with school-age children is about twice as large as that for all families. This finding suggests that the relative importance of district boundaries may have increased more for families with school-age children than for families without children.

Third, between-district school enrollment segregation increased by over 15% of the 1990 level and 25% of the 1990 standard deviation between 1990 and 2008. This increase is larger than the increase in residential segregation among families with school-age children, suggesting that high-income parents may increasingly enroll their children in private rather than public schools. This increase between 1990 and 2008 is driven not by increasing segregation of the poorest families from all others but by the lower-middle class becoming more segregated from the upper-middle class and the affluent. The decline in segregation of the bottom quintile is likely due to their integration with slightly higher-income families, not with middle or high-income families, which have become more segregated.

Finally, between-school enrollment segregation of FLE and non-FLE public school students increased within metropolitan areas during the 1990s but not during the 2000s. Segregation between schools within the 100 largest districts in the U.S. increased in both the 1990s and 2000s, with an overall increase of about 30% of the 1990 level and 60% of the 1990 standard deviation.

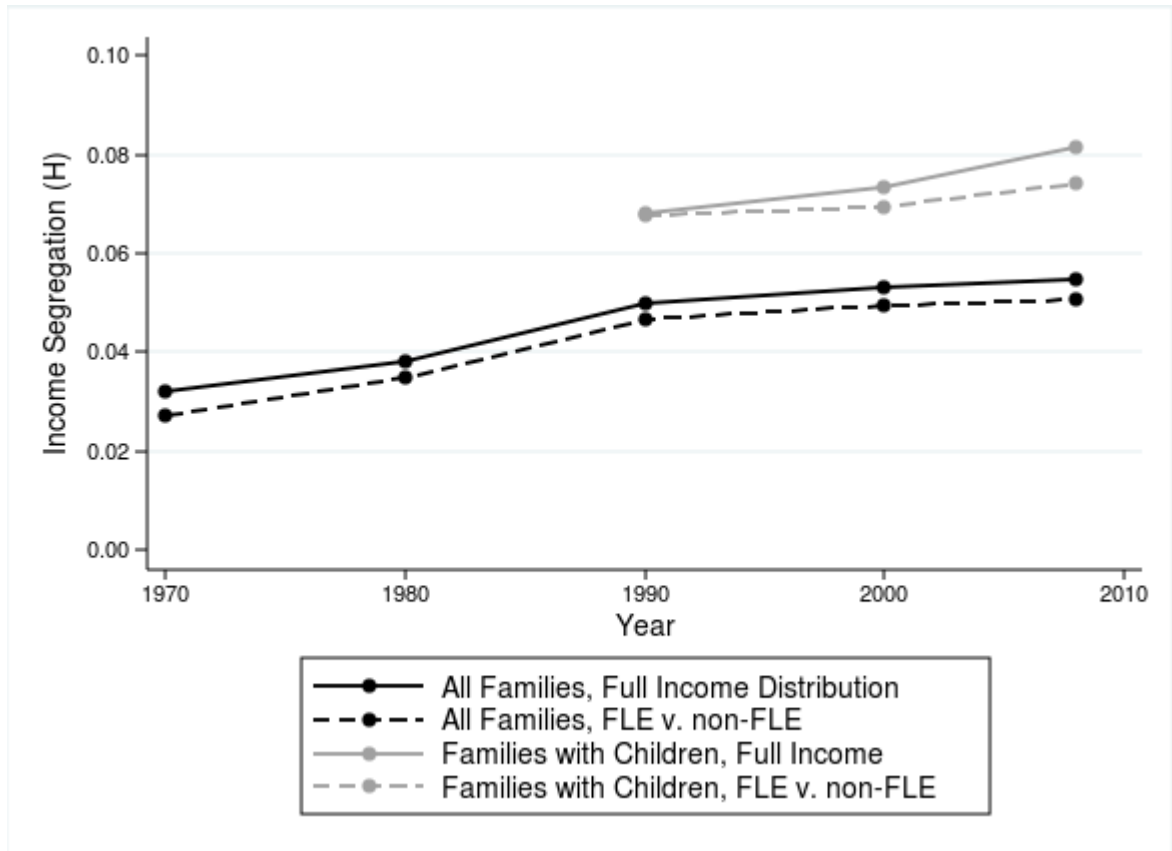
Between-district enrollment segregation of FLE and non-FLE students also increased from 1991 to 2010. Therefore, FLE students have become more concentrated in certain districts and in certain schools within districts over the past 20 years, which may result in resource inequalities at both the school and district levels. As is the case for racial segregation, segregation between school districts accounts for most of the total segregation of FLE and non-FLE students between schools. As a result, SES-based student assignment plans within districts can make only limited progress in reducing segregation by income as long as high levels of residential and enrollment segregation on the basis of income persists between districts.

Growing income segregation may have serious implications for resource disparities between districts, which may contribute to the economic achievement gap. First, districts comprised of more affluent students and parents usually have more resources than lower-income districts, potentially increasing the richer districts' relative achievement. Second, growing segregation between districts limits how diverse schools can be, as the student population in the district becomes more economically homogenous. School enrollment segregation by income is about 60% as large as black-white segregation and nearly as large as Hispanic-white segregation between districts, suggesting that income is an important source of stratification for public school students. Third, high levels of income segregation may affect political support for public education. High-income families generally have more political influence than low-income families, and high-income families in highly segregated metropolitan areas have little incentive to advocate for increases in metro- or state-wide school funding if their own high-income district has substantial resources.

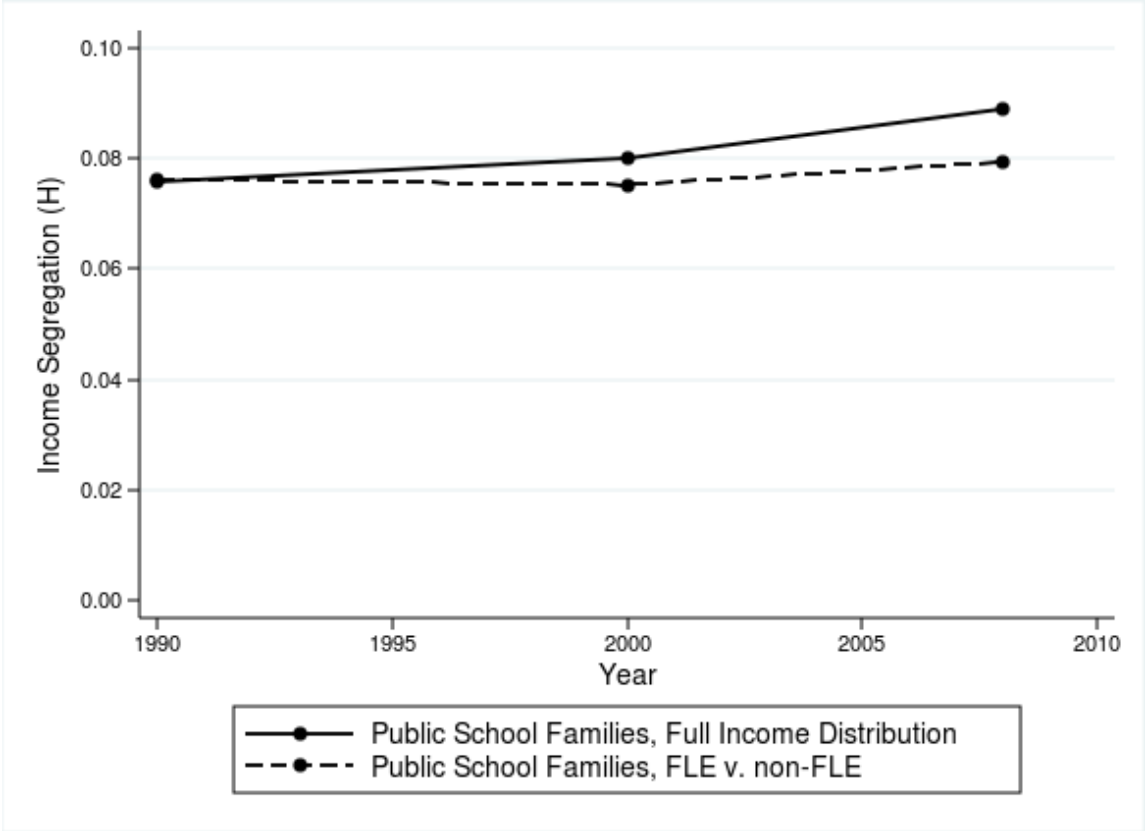
The results presented here suggest that residential segregation between school districts and enrollment segregation between schools and districts is considerably higher today than it was in 1970 and moderately higher than it was in 1990. Income segregation may be an increasingly important basis of educational disparities, with serious implications for educational inequality and

the economic achievement gap, which should be studied in future research. Future research must also consider the causes of economic segregation between schools and school districts, and our results offer several factors to consider. We find more segregation between districts among families with school-age children than among all families, which suggests that schooling considerations are an important factor in parents' residential choices, which in turn contribute to segregation. Further, segregation has increased more among families with children than among all families, suggesting that district boundaries and schooling concerns have become more important factors in residential sorting over the past several decades. Research has documented a growing class gap in investments in and concerns about children's schooling over the past several decades (Kornrich & Furstenberg, 2013; Ramey & Ramey, 2010), and our work suggests residential and school choice is another arena in which this occurs. Past research also shows that rising income inequality is one factor contributing to growing economic segregation between neighborhoods, suggesting that future research should investigate whether this is also the case for segregation between school districts. Our findings show that segregation increased most between upper-class families and all other families, consistent with an income inequality explanation, as the incomes of those at the top have pulled away from the rest of the population, allowing them to purchase educational advantages for their children in the form of residence in a particular district.

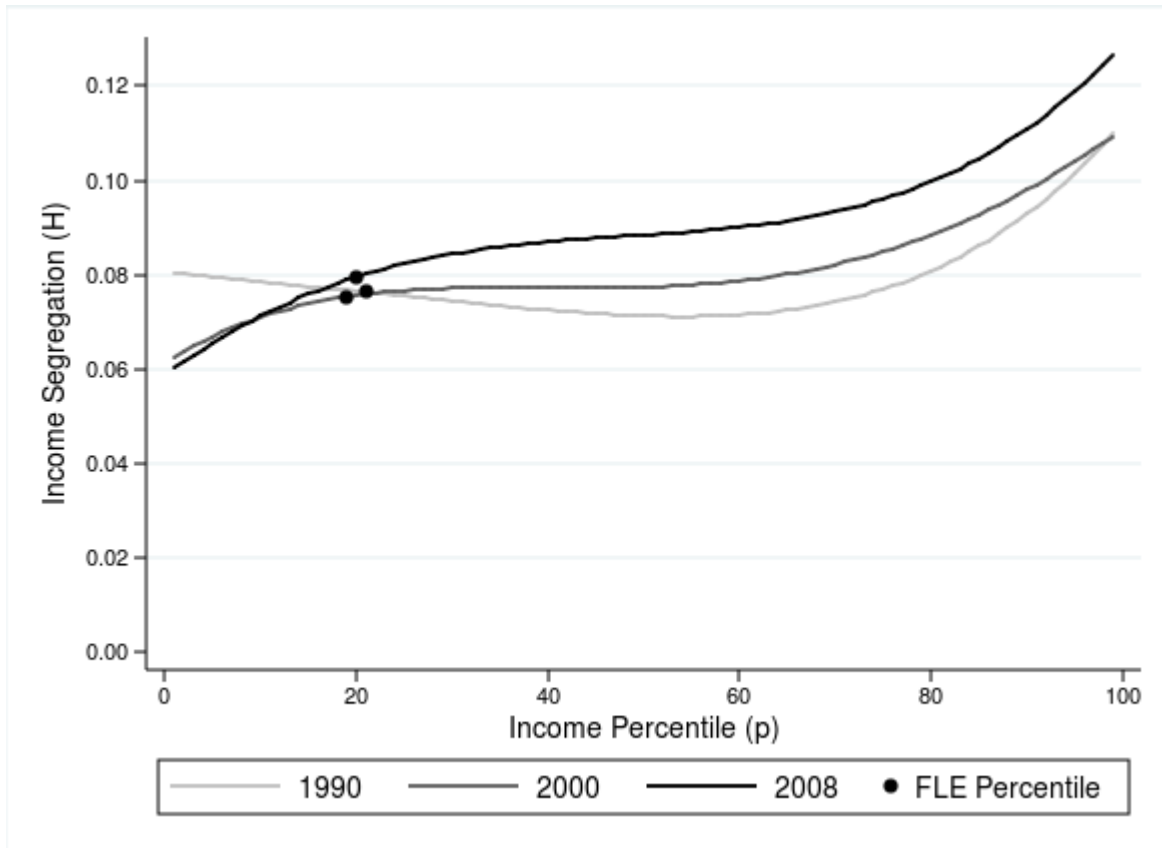
**Fig. 1** Average Between-District Residential Income Segregation of All Families and Families with School-Age Children within the 100 Largest Metropolitan Areas, 1970 to 2008



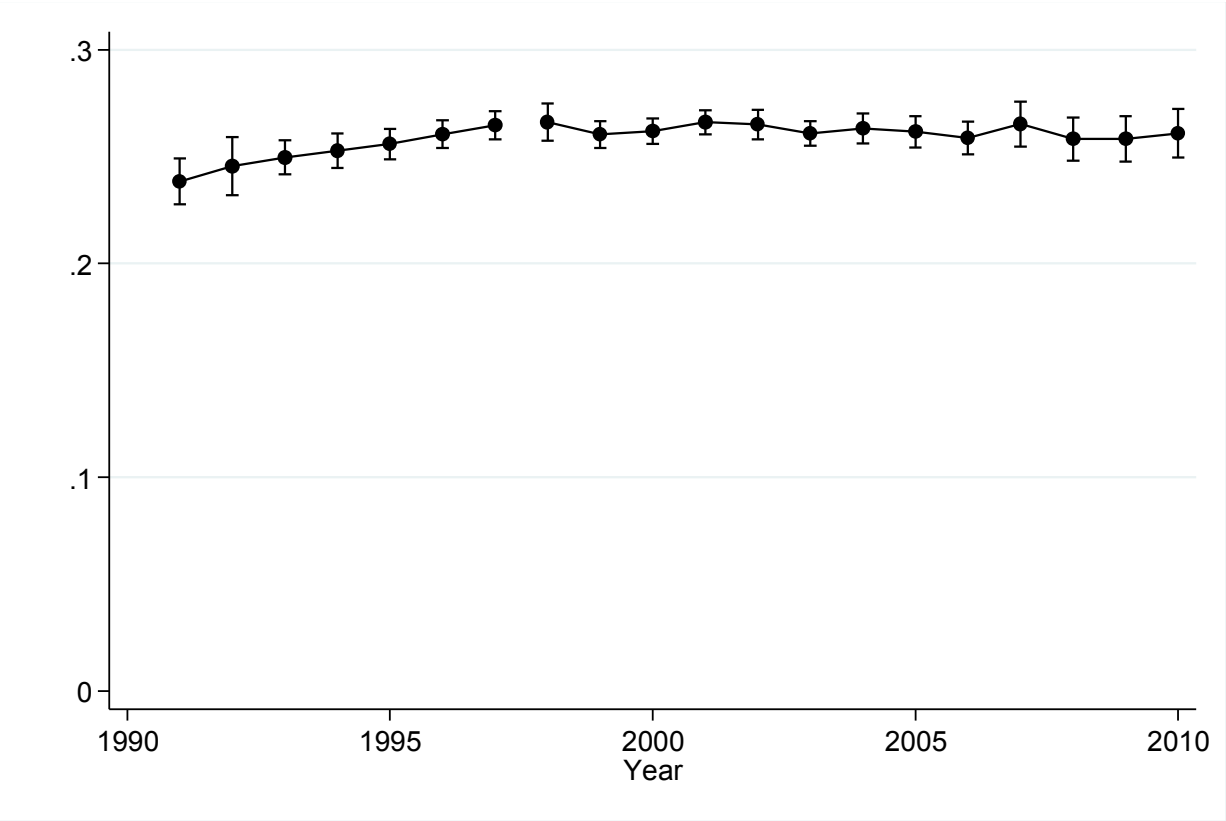
**Fig. 2** Average Between-District Income Segregation of Families with Children Enrolled in Public School within the 100 Largest Metropolitan Areas, 1990 to 2008



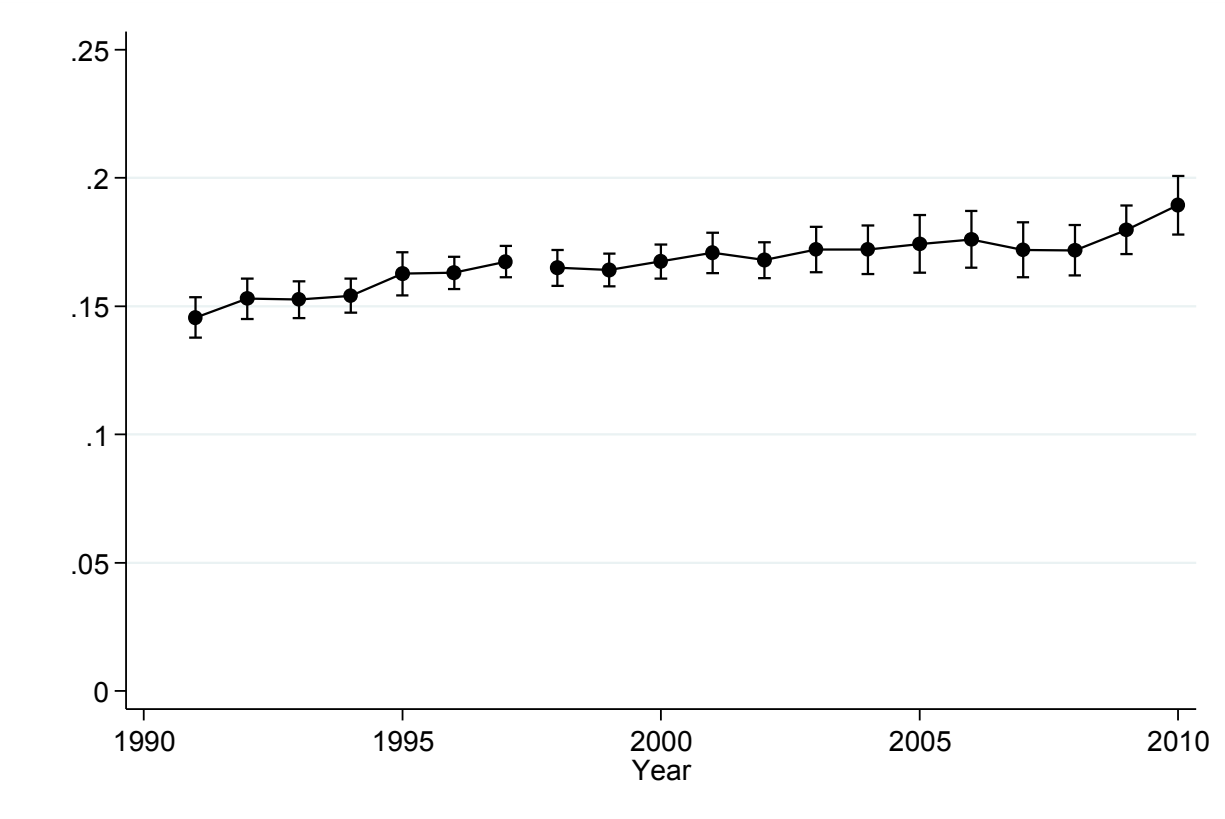
**Fig. 3** Average Between-District Income Segregation of Families with Children Enrolled in Public Schools, by Income Percentile, 100 Largest Metropolitan Areas, 1990 to 2008



**Fig. 4** Average Between-School Enrollment Segregation (Free-Lunch Eligible to non-Eligible) within the 100 Largest Metropolitan Areas, 1991 to 2010

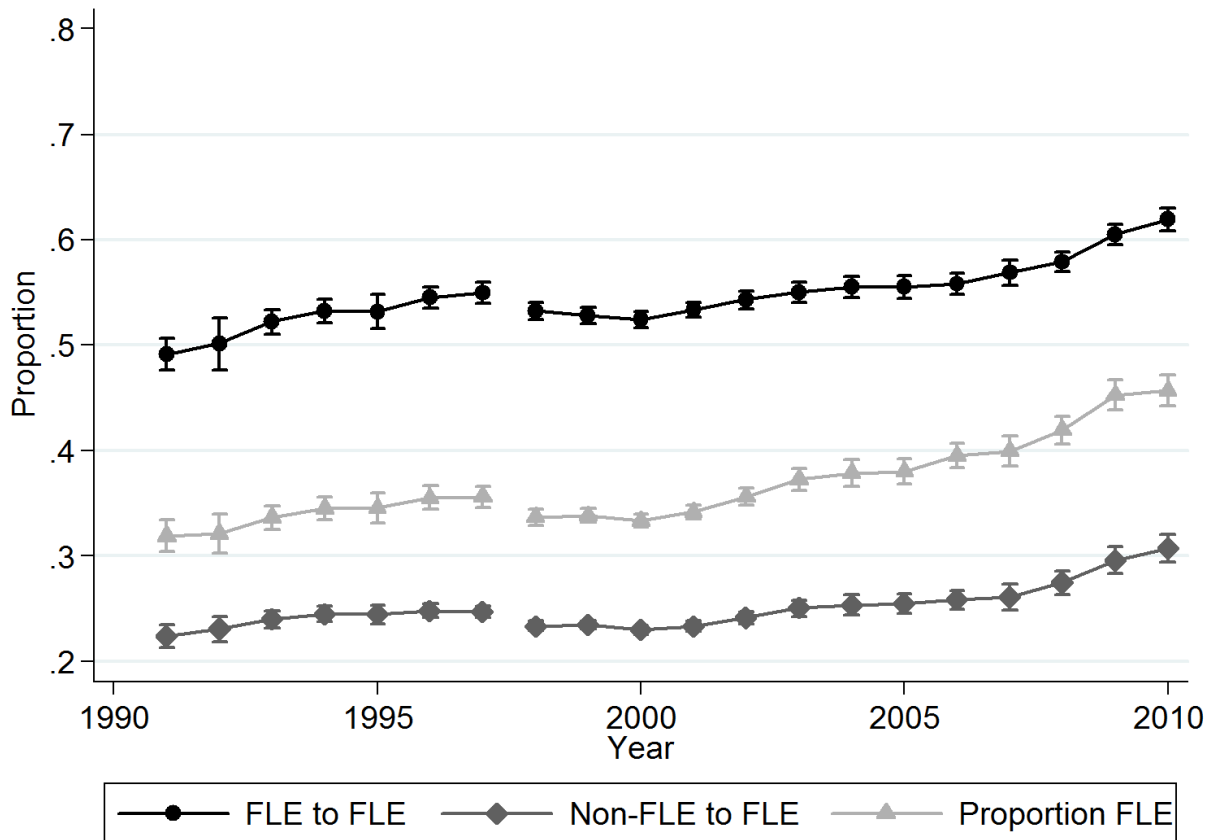


**Fig. 5** Average Between-School Enrollment Segregation (Free-Lunch Eligible to non-Eligible) within the 100 Largest School Districts, 1991 to 2010





**Fig. 6** Average Exposure Indices and Proportion FLE Students in Schools in the 100 Largest Metropolitan Areas, 1991 to 2010



Note: The FLE to FLE line displays the average proportion FLE in an FLE student's school. The Non-FLE to FLE line displays the average proportion FLE in a non-FLE student's school. The Proportion FLE line displays the proportion FLE students in schools.

Table 1. Mean (and Standard Deviation) of Between-District Residential, Between-District Enrollment, and Between-School Enrollment Segregation within 100 Largest Metropolitan Areas or Districts, 1970 to 2008/2010

|   | 1970             | 1980                | 1990                | 2000                          | 2008/2010 <sup>1</sup>        |
|---|------------------|---------------------|---------------------|-------------------------------|-------------------------------|
| <b>Between-District Residential Segregation</b> |                  |                     |                     |                               |                               |
| <i>Full Income Distribution Segregation</i>     |                  |                     |                     |                               |                               |
| All Families                                    | 0.032<br>(0.019) | 0.038***<br>(0.023) | 0.050***<br>(0.029) | 0.053***<br>(0.029)           | 0.055 <sup>^</sup><br>(0.031) |
| Families with School-age Children               | --               | --                  | 0.068<br>(0.041)    | 0.074***<br>(0.042)           | 0.082***<br>(0.046)           |
| <i>FLE-non FLE Segregation</i>                  |                  |                     |                     |                               |                               |
| All Families                                    | 0.027<br>(0.015) | 0.035***<br>(0.023) | 0.047***<br>(0.047) | 0.049**<br>(0.031)            | 0.051<br>(0.031)              |
| Families with School-age Children               | --               | --                  | 0.068<br>(0.045)    | 0.069 <sup>^</sup><br>(0.045) | 0.074***<br>(0.046)           |
| <b>Between-District Enrollment Segregation</b>  |                  |                     |                     |                               |                               |
| <i>Full Income Distribution Segregation</i>     |                  |                     |                     |                               |                               |
| Families of Public School Children              | --               | --                  | 0.076<br>(0.046)    | 0.080***<br>(0.046)           | 0.089***<br>(0.050)           |
| <i>FLE-non FLE Segregation</i>                  |                  |                     |                     |                               |                               |
| Families of Public School Children              | --               | --                  | 0.076<br>(0.051)    | 0.075<br>(0.048)              | 0.079***<br>(0.048)           |
| Public School Students <sup>2</sup>             |                  |                     | 0.154<br>(0.093)    | 0.169**<br>(0.097)            | 0.167<br>(0.159)              |
| <b>Between-School Enrollment Segregation</b>    |                  |                     |                     |                               |                               |
| <i>FLE-non FLE Segregation</i>                  |                  |                     |                     |                               |                               |
| Within Metropolitan Areas <sup>2</sup>          |                  |                     | 0.238<br>(0.089)    | 0.262***<br>(0.086)           | 0.261<br>(0.090)              |
| Within 100 Largest Districts <sup>2</sup>       |                  |                     | 0.146<br>(0.074)    | 0.171***<br>(0.073)           | 0.189***<br>(0.094)           |

Notes: Cells present mean segregation ( $H$ ) with standard deviations in parentheses. Asterisks indicate whether the estimate is significantly different from the estimate at the previous time point: \*\*\*  $p \leq 0.001$ ; \*\*  $p \leq 0.01$ ; \*  $p \leq 0.05$ ; <sup>^</sup>  $p \leq 0.10$ . Statistical significance is determined by regressing  $H$  on a set of year variables in a model with metropolitan area (or district) fixed effects.

1. For SDDS analyses of between-district segregation for families, the estimates in the 2010 column come from the pooled 2006-10 ACS. We refer to these as 2008 in text. The CCD analyses come from 2010.
2. For CCD estimates of between-school and between-district enrollment segregation of public school students, we report estimates in 1991, 2000, and 2010. There was a change in reporting FLE status from 1997 to 1998, but the estimates are very similar in both years, so we consider the overall trend from 1991 to 2000 accurate.

Table 2. Percent Change in Economic School Segregation in the 100 Largest Metropolitan Areas and School Districts, 1990 to 2008/2010

| Level of Segregation         | Population  | Full Income Distribution |           | FLE-non FLE    |           |
|------------------------------|---|--------------------------|-----------|----------------|-----------|
|                              |   | Percent Change           | SD Change | Percent Change | SD Change |
| Between-District Residential | All Families (SDDS)                                 | 10.0%                    | 0.172     | 8.5%           | 0.085     |
|                              | Families with Children (SDDS)                       | 20.6%                    | 0.341     | 8.8%           | 0.133     |
| Between-District Enrollment  | Families with Children in Public School (SDDS)      | 17.1%                    | 0.283     | 3.9%           | 0.059     |
|                              | Public School Students (CCD)                        | --                       |           | 8.4%           | 0.140     |
| Between-School Enrollment    | Public School Students (CCD)                        | --                       |           | 9.7%           | 0.258     |
|                              | Public School Students, 100 Largest Districts (CCD) | --                       |           | 29.5%          | 0.581     |

Notes:

1. Trends in SDDS data are from 1990 to 2006-10; trends in CCD data are from 1991 to 2010.
2. Cells present the percent change or the SD change in terms of 1990 SD in segregation (*H*) for each level of segregation, population, and income classification
3. All changes between 1990 and 2010 are statistically significant.

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## **Appendix A: Data and Measurement**

### *School District Demographic System*

Data on family income at the school district level in 1970 was assembled by linking the School District Geographic Reference File, 1969-1970 to Census data. The School District Geographic Reference File (U.S. Department of Commerce, 1970) provides the numbers of tracts and Enumeration Districts (EDs) within district boundaries for every district in the U.S. (except in Maryland) with enrollments of 300 or more students (about 12,000 districts); districts with enrollments of 300 or less in the Elementary & Secondary Education General Information Survey (ELSEGIS) sample; and all school districts in IL, KS, and NY. The data also include a variable indicating the percent of the tract or ED within district boundaries. We obtained family income counts in 15 categories for census tracts from the 1970 Census (through the Neighborhood Change Database produced by Geolytics). We obtained family income counts in 15 categories for EDs (in areas that were untraced) through ICPSR Study 0964 (Adams 2007). Then, to get district-level counts of families in income categories, we multiplied the counts by the percent of the tract or ED in the district and then summed the counts to the district level.

School district data in 1980 come from the Census of Population and Housing, 1980: Summary Tape File 3F, School Districts. This file includes family income data in 17 categories already aggregated to the district level, so untraced areas are already accounted for. Data are missing for the metropolitan area of Fairbanks, AK.

In 1990, several counties in CA did not participate in the Census Mapping Project which provides school district boundaries. We are missing income data in Tehama, Madera, Humboldt, El Dorado, San Francisco, San Benito, Napa, Monterey, and Del Norte counties. Therefore, CA estimates for 1990 do not include these counties. Estimates excluding CA altogether in all years are nearly identical to estimates reported here, so the rest of CA was retained in analyses.



### *Measuring Segregation with the Rank-Order Information Theory Index*

To measure income segregation, we use the *rank-order information theory index* (Reardon, 2011a), which measures the ratio of within-unit (school or school district) income rank variation to overall (state or metropolitan area) income rank variation. For any given value of  $p$ , we can dichotomize the income distribution at  $p$  and compute the residential (pairwise) segregation between those with income ranks less than  $p$  and those with income ranks greater than or equal to  $p$ . Let  $H(p)$  denote the value of the traditional information theory index of segregation computed between the two groups so defined (Theil & Finezza, 1971; Theil, 1972; Zoloth, 1976). Likewise, let  $E(p)$  denote the entropy of the population when divided into these two groups (Theil & Finezza, 1971; Theil, 1972). That is,

$$E(p) = p \log_2 \frac{1}{p} + (1 - p) \log_2 \frac{1}{(1 - p)}$$

and

$$H(p) = 1 - \sum_j \frac{t_j E_j(p)}{TE(p)},$$

where  $T$  is the population of the state or metropolitan area and  $t_j$  is the population of school or district  $j$ . Then the rank-order information theory index ( $H^R$ ) can be written as

$$H^R = 2 \ln(2) \int_0^1 E(p) H(p) dp$$

Thus, if we computed the segregation between those families above and below each point in the income distribution and averaged these segregation values, weighting the segregation between families with above-median income and below-median income the most, we get the rank-order information theory index. The rank-order information theory index ranges from a minimum of 0, obtained in the case of no income segregation (when the income distribution in each local environment (e.g. school district) mirrors that of the region as a whole), to a maximum of 1, obtained in the case of complete income segregation (when there is no income variation in any local

environment). A more thorough explanation of this technique (and its rationale) is provided elsewhere (Reardon & Bischoff, 2011b; Reardon, 2011a).

## **Appendix B: Estimates of Free-Lunch Eligibility Rates and Enrollment in the National School Lunch Program**

In the following figures, we report estimates of FLE rates and counts of students receiving free lunch in schools. The data come from several sources:

### Measures from the annual March Current Population Survey (CPS):

- Total number of children ages 6-18
- Total number of children ages 6-18 eligible for free lunch (family income is 130% or less of the poverty line) [includes children in private schools and dropouts]
- Total number of children ages 6-18 eligible for reduced priced lunch (family income is 130-185% of poverty line) [includes children in private schools and dropouts]

### Measures from National School Lunch Program Website:

<http://www.fns.usda.gov/pd/slsummar.htm>

- Number of students receiving free lunches (daily average of number of lunches served) [includes children in private schools]

### Measures from Common Core of Data:

- Total number of students attending public schools in the U.S.
- Total reported number of students receiving free lunches in public schools in the U.S. (adjusted to account for missing data, by assuming that the rate of FLE among those with missing FLE status is the same as the rate among those for whom FLE is reported)

Of particular interest are the numbers/proportions of students eligible for free lunch (based on CPS), the numbers/proportions of students receiving free lunch (as reported by NSLP), and the numbers/proportions of students receiving free lunch (as reported in the CCD). Figure B1 shows the proportion of children eligible for free lunch and reduced-price lunch and the proportion of children in poverty since 1980. The proportion of children eligible for free price and reduced price lunch tracks fairly closely with the proportion of children in poverty. Note that free lunch eligibility

rates declined from 1984-1990, and again from 1994-2001, and rose in the intervening periods. CPS data indicate rates of eligibility have ranged from 23-30% over the last 30 years.

[Figure B1 about here]

Figure B2 presents the trend in the number of children eligible for free lunch according to the CPS (solid black line), the number of students receiving free lunch according to the NSLP (solid gray line), and the estimated number of students eligible for free lunch based on CCD data (dotted grey line).

[Figure B2 about here]

Figure B3 shows the same trends in terms of proportion of children rather than raw number. Note that in Figure B2 and B3, CCD estimates of FLE students are much higher (as much as 30% higher in recent years) than CPS estimates of eligible children. CCD rates are also roughly 10 percentage points higher than the numbers implied by NSLP data, though the trend is similar. Both estimates of the number of children receiving free lunches (from CCD and NSLP) show more increase since 1990 than the increase in eligibility rates implied by CPS data.

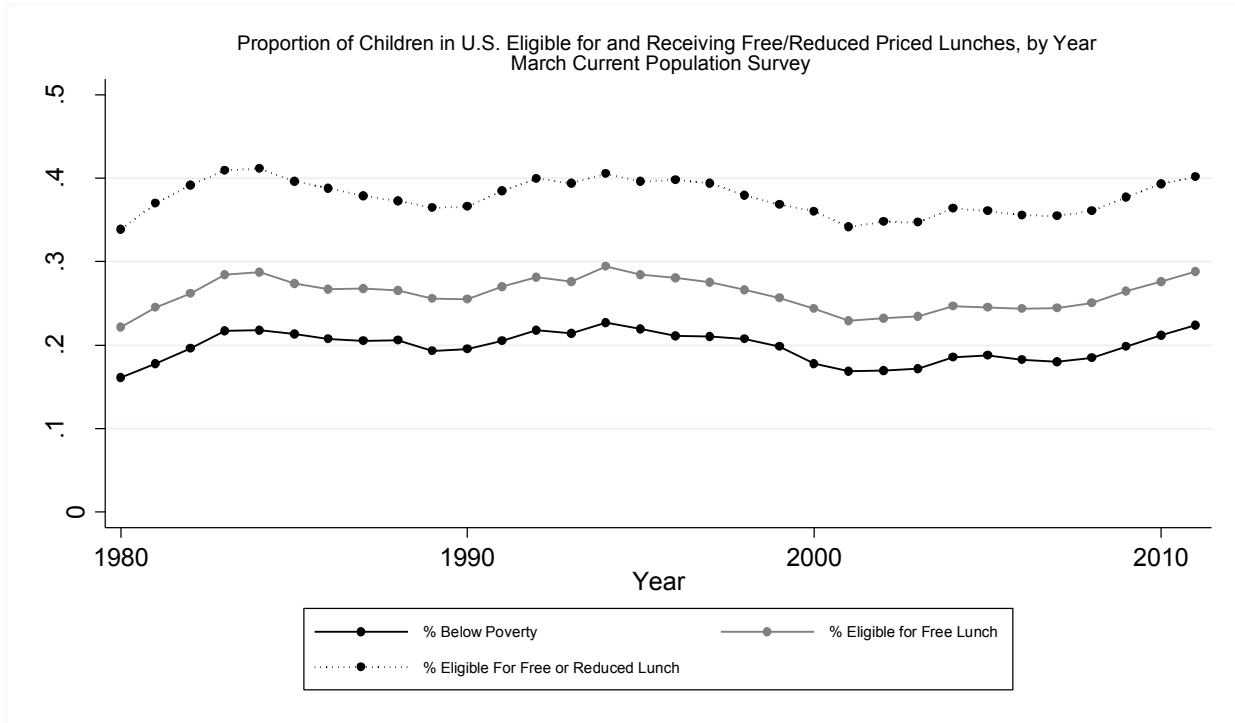
[Figure B3 about here]

If the CCD inflates counts of FLE students more in schools where there are more “true” FLE students, segregation estimates will be inflated. To test if this is the case, we compared counts of FLE students at the district level from CCD and from the SDDS (estimating FLE cutoff as described above). Figure B4 presents the percent of FLE students, according to the CCD data, in a school district on the y-axis and the percent of public school students whose family income is below 130% of the poverty line, according to SDDS data, on the x-axis. The black line is a lowess line fitted to the data, suggesting that the proportion of FLE students in the CCD data is increasingly inflated as the proportion of “true” FLE eligible students rises, peaking at about 0.5. This inflation increases over time from 1990 to 2009 (not shown), suggesting that the positive trend in segregation could be an artifact of the data. Unfortunately, we have no other comprehensive national longitudinal data

source on students' income at the school or district level.

[Figure B4 about here]

**Fig. B1**



**Fig. B2**

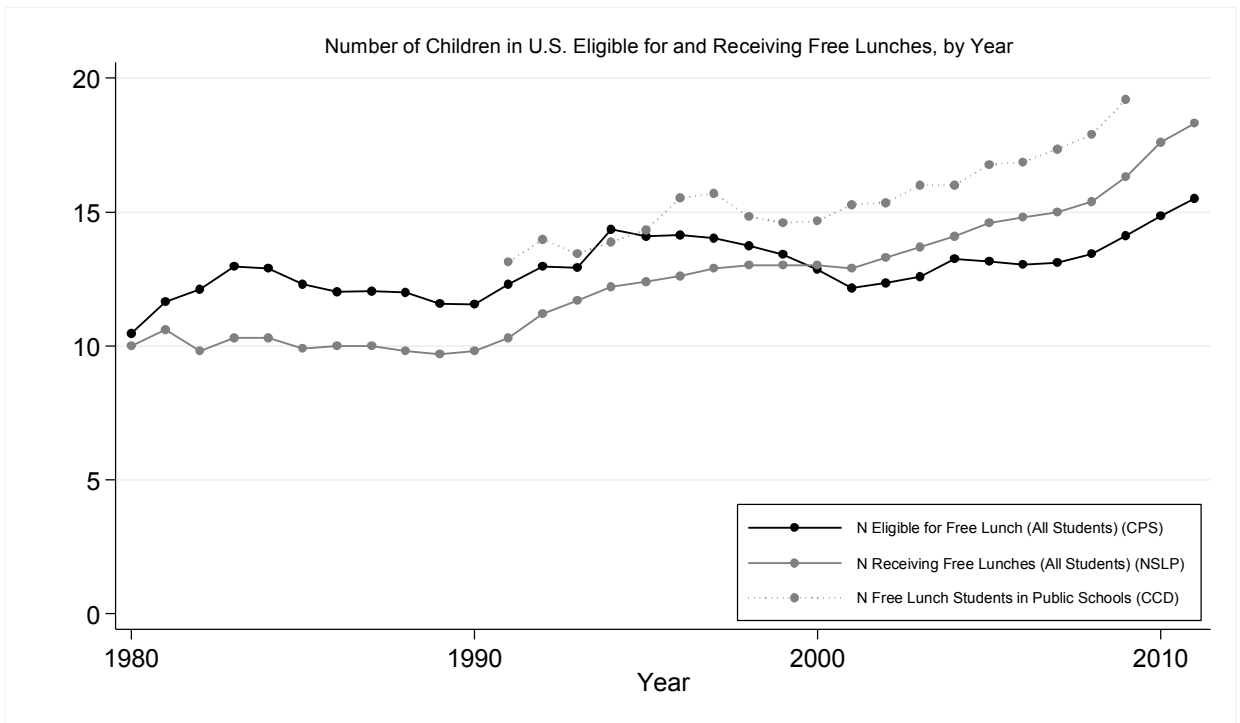
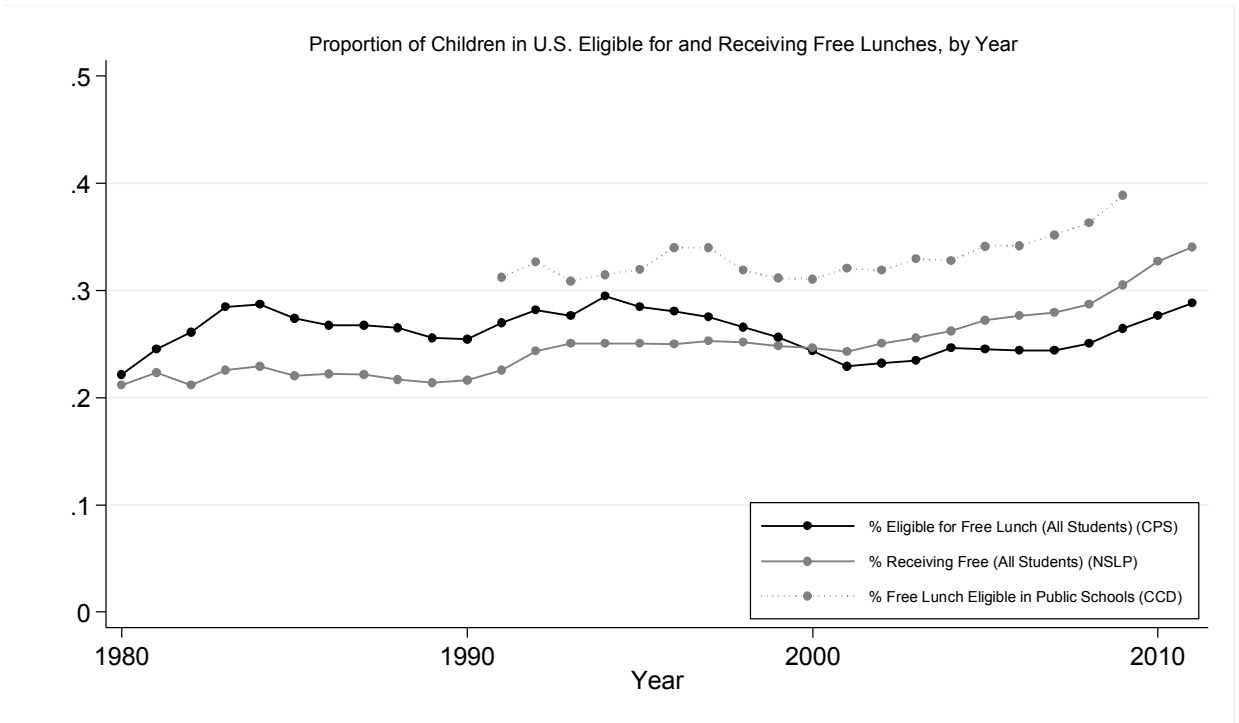
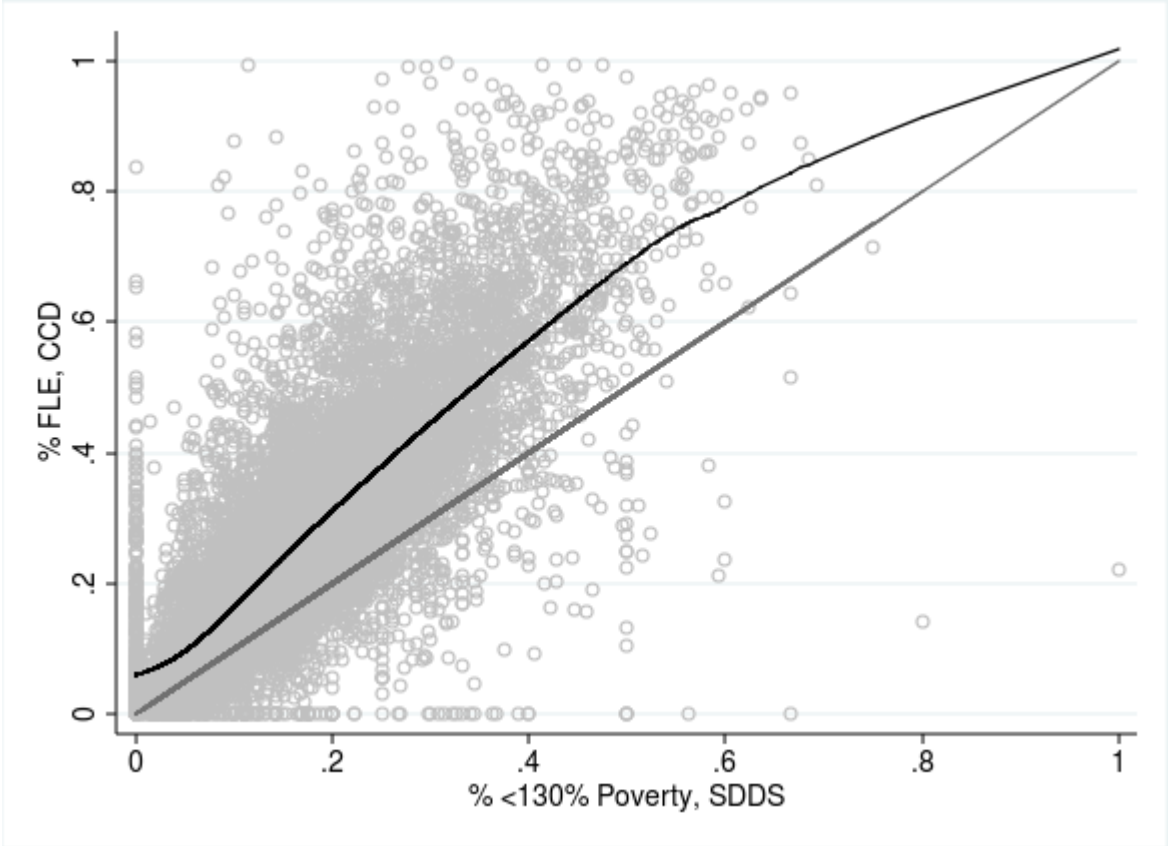


Fig. B3



**Fig. B4** Relationship between FLE students in SDDS and CCD in All School Districts, 2000



Notes: Each dot represents a school district. The black line is a loess smoothed line and the gray line is a 45 degree reference line.