Estimating School District Poverty with Free and Reduced-Price Lunch Data *

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Abstract

The Small Area Income and Poverty Estimates (SAIPE) program of the U.S. Census Bureau produces model-based estimates of the number of school-age children in poverty in states, counties and school districts. This research explores the use of free and reduced-price lunch (FRPL) eligibility counts for estimating poverty in school districts. Through regression analysis we estimate a positive relationship between FRPL data and Census 2000 poverty estimates with a median prediction error of 30 percent. The high degree of prediction error suggests the FRPL data are not sufficiently precise for formal use in producing school district poverty estimates at this time.

Keywords: small area estimates, poverty, school districts, free and reduced-price lunch

1. Introduction

The U.S. Census Bureau's Small Area Income and Poverty Estimates (SAIPE) program (Census Bureau, 2006a) annually produces estimates of the number of related children ages 5 to 17 in poverty for states, counties and school districts. Direct survey-based estimates of poverty levels from the Annual Social and Economic Supplement of the Current Population Survey (CPS ASEC) are combined with regression model predictions of poverty levels based on data from administrative records and Census 2000 to produce model-based state and county estimates. The school district poverty estimates are produced using a synthetic approach, utilizing the sub-county distribution of poverty from the most recent decennial census relative to the SAIPE program's model-based county estimates. These estimates are consistent with the official national poverty estimate from the CPS ASEC. The Department of Education, under the No Child Left Behind Act of 2001, uses these estimates in its funding allocation formulas to apportion roughly $13 billion to eligible school districts (DOE, 2006).

A limitation of the current methodology is that it does not allow for change in the sub-county distribution of poverty between decennial censuses. Since the sub-county distribution of poverty is assumed constant in intercensal years, most of the fluctuation in school district estimates is due to fluctuation in county estimates. As a result, to the extent that the sub-county distribution of poverty changes over the years, the accuracy of the school district estimates diminishes as the decade progresses.

In an effort to improve the school district poverty estimates for intercensal years, the SAIPE program considers sub-county data that may be related to poverty status. The National Academy of Sciences recommended research incorporating information from reported FRPL eligibility counts (National Research Council, 2000). This study tests for a relation between FRPL counts from the U.S. Department of Education's National Center for Education Statistics (NCES) and poverty estimates from Census 2000. If FRPL data are a reliable sub-county indicator of poverty incidence in the year of the decennial census, then, as FRPL data are available each year, they might provide guidance about poverty during intercensal years.

2. National School Lunch Program

The National School Lunch Program (NSLP) was established under the National School Lunch Act in 1946 and was most recently extended by Congress in 2004 under the Child Nutrition and Women, Infants and Children Reauthorization Act of 2004 (P.L. 108-265). The Food and Nutrition Service (FNS) of the U.S. Department of Agriculture administers the NSLP, which provides free meals to eligible children in households with income at or below 130% of the federal poverty guidelines, and reduced-price meals to eligible children in households with income above 130% and at or below 185% of these guidelines.

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During fiscal year 2005, roughly 17.1 million children received free or reduced-price lunch – 14.3 million for free lunch and 2.8 million for reduced-price lunch (FNS, 2006a).

Schools qualify applicants for the FRPL program after reviewing reported current monthly household income and household size. Children in households participating in the Food Stamp Program, Temporary Assistance for Needy Families Program, or Food Distribution Program on Indian Reservations are automatically eligible for FRPL enrollment. This type of eligibility is known as direct certification or categorical eligibility (Gundersen, et al., 2003).

Between 1994 and 2004, the ratio of school-age children receiving free or reduced-price lunch increased from 28.6 to 32.2 percent, using state-level data from the FNS (FNS, 2006a). For the same time period, the estimated poverty rate for related children ages 5 to 17 decreased from 19.8 to 16.2 percent, using data from the CPS ASEC. These time trends are shown in *Figure 1* below.

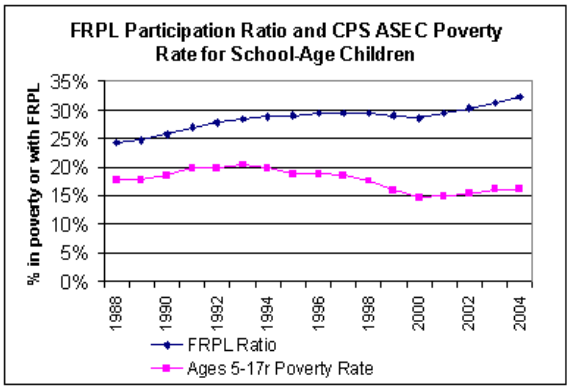

Figure 1: FRPL participation ratio and poverty rate of related children ages 5-17, 1988 to 2004. Source: FRPL data from FNS (FNS, 2006a) and poverty estimates from CPS ASEC (Census Bureau, 2006b).

To understand what the FRPL data measure, it is helpful to consider some issues related to FRPL reporting by school districts. There are currently few safeguards to ensure that all those enrolled in FRPL are legitimate enrollees. While the Income and Eligibility Verification system (SSA, 2006) applies to other entitlement programs such as Medicaid and the Food Stamp Program, it does not apply to enrollees in FRPL. Federal rules do not require documentation of monthly household income or of ongoing benefits at the time of FRPL application, and only a small percentage – from 1.5 to 3.0 percent – of FRPL applications must be verified (FNS, 2006b). Students can continue to receive free or reduced-price meals during the school year even if monthly household income increases above the eligibility threshold after application.

A further challenge to FRPL enrollment is that schools often have a financial incentive to enroll and certify as many students into the FRPL program as possible (DOE, 2005). States and school districts frequently utilize the number of students receiving free and reduced-price meals to apportion Title I grants and many types of state and local funding. For instance, teacher and student loan forgiveness programs, literacy and reading grants, the E-rate initiative (for telecommunication and Internet expenses), and vocational and technical education funding are several programs that use FRPL data as a basis for deciding how to distribute resources.

Since many FRPL enrollees declare income below the federal poverty guideline when applying for FRPL, the count of FRPL enrollees in school districts may contain valuable information about the count of children in poverty. Despite some reporting and enrollment challenges, these FRPL data may be of value for estimating poverty in years where other data that measure poverty directly are not available.

3. Data

3.1 FRPL Data from NCES

The FRPL data used in this analysis are collected from schools by NCES through its Public Elementary/Secondary School Universe Survey (NCES, 2006) and are available through NCES' Common Core of Data. The data are comprised of survey-reported administrative records from over 89,000 schools, including charter and magnet schools. For this analysis, individual school data are aggregated to school districts in order to form total reported numbers of students who receive FRPL for each school district. Note that these FRPL data from NCES are different from the state-level FRPL data from FNS shown in Figure 1.

Not all schools or school districts report their FRPL counts in the NCES survey. For school year 1999-2000, only twenty-three states have data for all school districts; four states report no data, and the remaining twenty-four states have missing data for up to 27 percent of their districts. Overall, FRPL data are not reported for 1,941 school districts (13.6 percent) of the 14,262 total school districts. In addition, among the 12,321 districts that report data, 545 school districts are missing data from some constituent schools, so that complete FRPL data are

available for only 11,776, or 83 percent of all school districts. As described in Section 4, our analysis considers only districts with complete FRPL data.

School district level FRPL data may be missing for a number of reasons. Some schools may be unwilling to fill out certain items in the NCES survey or may choose not to participate in NSLP. It could be the case that individual schools or school districts may not report data to their state agencies, or that state agencies may not report all data to NCES. An additional source of partial reporting relates to direct certification of FRPL eligibles. In some states, students who are directly certified do not need to complete an application for the FRPL program (FNS, 2005) and consequently may not always appear in reported FRPL counts.

An important difference between the FRPL data and the Census 2000 data is that FRPL data only reflect students who apply and are eligible for free and reduced-price lunch at public and non-profit private schools, while Census 2000 poverty estimates measure the poverty status of all students living in a given geographical area regardless of school type or school of attendance. Also, as of 2003, forty-three state legislatures had enacted open enrollment laws with provisions for students to transfer between districts (Education Commission of the States, 2006). In the reported FRPL counts, students relocating during a school year may be counted in multiple districts, and students enrolled for only part of the school year may be counted as participating for the entire year.

3.2 Data from Census 2000

For our comparison with FRPL data, we use Census 2000 poverty estimates from the Census 2000 long-form survey, which was provided to roughly one in six households nationwide and refers to reported income data from 1999 (Census Bureau, 2006c). All related children[1] within a family are considered living in poverty if the family income is at or below the official 1999 poverty threshold for that family. As with any survey-based data, the number of sample cases per area affects the estimates and the associated sampling error. Poverty estimates for districts with fewer sample cases generally have higher sampling error than those for districts with more sample cases.

The Census 2000 school district poverty estimates correspond with particular legal boundaries and associated populations. A child need not be enrolled in a school in order to be counted among the local school district population. School district population comes from the Census 2000 short-form, and consists of all grade relevant children residing within the geographic boundaries of a given school district.

Grade relevance is important when two school districts have overlapping boundaries and occupy some of the same territory, e.g., when one district provides elementary education for grades K through 8, and another district in part of the same geographical area provides secondary education for grades 9 through 12. Based on a child's age in the decennial census and the grade spans of the elementary and secondary districts, each child is then assigned to a specific grade and counted among either the elementary or the secondary school-age population in that area.

3.3 Differences between FRPL and Census Data

FRPL counts are conceptually different from the decennial census poverty estimates for several reasons. First, there are slightly different criteria used in determining basic poverty status. The Census Bureau determines poverty status by comparing family income to the official *federal poverty thresholds* (Census Bureau, 2006), while FNS determines FRPL eligibility by comparing household income to the *federal poverty guidelines* issued by the Department of Health and Human Services (HHS, 2006). The poverty thresholds are generally used for statistical purposes, while the poverty guidelines are generally used to determine eligibility for social programs. Note that while family income is used to create official poverty estimates, FRPL eligibility is based on household income, which is always greater than or equal to family income since household income may also include income from unrelated individuals in the household.

A second reason FRPL counts differ from Census 2000 poverty estimates is that the income ceiling for FRPL eligibility is higher than the official poverty threshold. Children are eligible for free or reduced-price lunch as long as household income does not exceed 185% of the HHS poverty guideline. It turns out that a large share of families (13.7% in 2004)[2] have income between the poverty threshold and

[1] Related children are children related to their householder by birth, marriage or adoption. Foster children, for example, are not included among related children.

[2] Computed using published CPS ASEC data from (Census Bureau, 2005).

185% of the poverty threshold. As a result, in most school districts many more children are eligible for FRPL than are living in poverty. The corresponding FRPL data and Census 2000 poverty estimates differ consistently and by varying amounts across districts.

FRPL counts may be higher than Census 2000 child poverty estimates additionally because FRPL eligibility is based on monthly income rather than annual income. In a given month, the number of families with *monthly* income less than or equal to 185% of the poverty guideline is usually higher than the number of families with *annual* income less than or equal to 185% of the poverty guideline (Neuberger, 2003) and (Census Bureau, 1998).

Direct comparisons of the Census 2000 poverty and population data with the FRPL data show some apparent inconsistencies. Two districts have no children from the Census 2000 short-form, yet, in the FRPL data, report 22 and 12 enrolled students and 12 and 9 FRPL participants, respectively. Additionally, there are 33 school districts with no Census 2000 long-form data for school-age children and 397 districts reporting zero school-age children in poverty. These observations may reflect sampling or statistical error of the Census 2000 long-form survey, incorrect district assignment by NCES or FNS, or different definitions of a school district.

Despite these differences between reported FRPL data and Census 2000 poverty estimates, FRPL data may still provide the most current, reliable and direct sub-county measure of low-income status for school-age children available. Including FRPL data in school district poverty models could be helpful, particularly if FRPL data are available for some of the smallest districts, where other data sources are limited.

4. Modeling FRPL and Poverty

In order to assess whether FRPL data provide information about school-age children in poverty, we compare these data with Census 2000 direct survey-based poverty estimates. We run regression models at the school district level with FRPL eligibility counts as the independent variable and Census 2000 ages 5-17 related poverty estimates as the dependent variable. We estimate trend relationships and study how often school districts differ from these trends.

The universe we examine is the 14,262 school districts identified from Census 2000 that have corresponding NCES data for school year 1999-2000. As discussed in Section 3.1, many school districts lack full FRPL data, and we do not consider these districts in our analysis. Of the 14,262 school districts, there are 1,941 school districts missing FRPL data entirely and 545 districts with only partial data. Of the remaining 11,776 school districts with full reporting, 34 districts have FRPL counts that appear implausible. The FRPL counts in these 34 districts are extremely high or are extremely low or have very large changes between 1999 and 2000.[3] In a production environment, these outlier FRPL counts would likely be imputed, and in this analysis they are not considered. Lastly, since our models use logarithms, which are undefined for zero, we do not consider 558 school districts reporting either zero FRPL recipients or zero Census 2000 poverty. As a result, we include 11,184 school districts in this analysis.

4.1 Models

The models are run in three forms: log-levels, log-ratios and log-odds ratios (also known as logit or logistic). Logarithms are taken of all data to stabilize the variance and to make the distributions of the variables more symmetric and normal. Modeling data in log-ratios or in log-odds ratios helps eliminate level effects and focuses on the *extent* of poverty in each district regardless of size. The log-odds ratios model transforms the Census 2000 poverty ratio into an odds format, which constrains model predicted ratios between 0 and 1. Because the specifications of the variables are different for each model, the estimated beta coefficients and fit statistics are not directly comparable across models.

We define FRPL ratios, Census poverty ratios, and log-odds ratios as follows:

$$\text{FRPL ratio} = \left(\frac{\text{FRPL number}}{\text{district enrollment}} \right)$$

$$\text{Census poverty ratio} = \left(\frac{\text{Census 2000 number in poverty}}{\text{Census 2000 poverty universe}} \right)$$

$$\text{log-odds(FRPL ratio)} = \ln\left(\frac{\text{FRPL ratio}}{1-(\text{FRPL ratio})} \right)$$

[3] Of these 34 districts, 11 districts have FRPL counts over 5 times as large in 2000 as in 1999, 6 districts have FRPL counts less than 15% as large in 2000 as in 1999, 2 districts have FRPL counts over 40 times the Census 2000 poverty estimate, and 15 districts have FRPL counts less than 5% of the Census 2000 poverty estimate.

log-odds(Census poverty ratio) =

$$\ln\left(\frac{\text{Census poverty ratio}}{1-(\text{Census poverty ratio})}\right)$$

We run the models using weighted least-squares regression. The weights are based on the coefficient of variation of the Census 2000 ages 5-17 related poverty estimate. As a result, sample observations in Census 2000 with higher precision receive greater weight in fitting the regression lines.

$$\text{Weights} = \frac{1}{\frac{\text{standard error Census 2000 poverty estimate}}{\text{Census 2000 poverty estimate}}} = \frac{1}{\text{CV of Census 2000 poverty estimate}}$$

The models tested follow below:

Log-Levels ln(Census poverty number) = $\beta_0 + \beta_1 \ln(\text{FRPL number}) + \mu + \varepsilon$,

Log-Ratios ln(Census poverty ratio) = $\beta_0 + \beta_1 \ln(\text{FRPL ratio}) + \mu + \varepsilon$,

Log-Odds log-odds(Census poverty ratio) = $\beta_0 + \beta_1 \text{log-odds}(\text{FRPL ratio}) + \mu + \varepsilon$,

where μ is the sampling error of the dependent variable and ε is the model error. The sampling error and model error are assumed to be normally distributed and independent across school districts.

4.2 Estimation

Results from model estimation are in *Table 1* below.

Log-Levels ln(Census poverty number) =
-0.62 + 0.97*ln(FRPL number)
(-38) (416) AIC = 15916 F=172718

Log-Rates ln(Census poverty ratio) =
-1.09 + 0.82*ln(FRPL ratio)
(-160) (153) AIC = 13717 F=23375

Log-Odds log-odds(Census poverty ratio) =
-1.52 + 0.59*log-odds(FRPL ratio)
(-320) (152) AIC = 17503 F=23224,
where the t-statistics are in parentheses.

Table 1: Estimation results for log-levels, log-ratios and log-odds ratios models.

The FRPL variable is consistently informative and statistically significant for predicting Census 2000 poverty. Because of the different data transformations used in the three models, the regression coefficients and model fit statistics cannot be directly compared to one another. Converting model predictions back into predictions of the number of children in poverty, as is done in Section 4.3, is necessary to show which models produce the best fitted-value estimates.

In the log-levels model, a one-percent increase in FRPL counts is associated with a 0.97-percent increase in the number of children in poverty in Census 2000. In the log-ratios model, a one-percent rise in FRPL ratio is associated with a 0.82-percent rise in the child poverty ratio. In the log-odds ratios model, a one-percent rise in the odds of the FRPL ratio leads to an estimated 0.59-percent rise in the odds of the child poverty ratio. That these estimated coefficients are less than one (and that the intercepts are estimated to be negative) is expected since most school districts have larger FRPL counts than Census 2000 ages 5-17 related poverty estimates.

Since the quality of FRPL reporting varies by state, the relationship between FRPL counts and Census 2000 child poverty may vary by state as well. The models are also run with *state random intercepts* to test and control for state heterogeneity and unmodeled state-specific factors. State random intercepts are illustrated for the log-odds ratios model (which, according to Section 4.3, provides the best fit with the data) below.

Log-Odds log-odds(census poverty ratio) = $\beta_0 + \beta_1 \text{log-odds}(\text{FRPL ratio}) + \beta_{2i} + \mu + \varepsilon$,
where *i* varies by state

Estimation with state random intercepts appears to eliminate some modest state clumping in model residuals, and the chi-square value from the likelihood ratio test (with one degree of freedom) for inclusion of random intercepts is 796, 791 and 799 for the log-levels, log-ratios and log-odds ratios models, respectively, each of which is greater than the 10 percent critical value of 2.71. Although the random intercepts are not individually significant for about twenty states, the overall explanatory power of the model improves through inclusion of random intercepts. Estimation results for the log-odds ratios model with random intercepts follow in *Table 2*.

Log-Odds log-odds(poverty ratio) =
-1.55 + 0.56*log-odds(FRPL ratio) + $\hat{\beta}_{2i}$
(-65) (131) AIC = 16706 F=17226,
where the t-statistics are in parentheses.

Table 2: Estimation results for log-odds ratios with random intercepts model.

This model estimates that a one-percent rise in the odds of the FRPL ratio is associated with a 0.56-percent rise in the odds of the child poverty ratio. This is lower than the 0.59-percent estimate from the log-odds ratios model without random intercepts (and the difference is statistically significant). That the coefficient estimate with random intercepts is lower than the estimate without them is not surprising since some of the variation in Census 2000 poverty is now attributed to state level variation rather than entirely to school district variation in FRPL counts.

4.3 Discussion of Results

Since the SAIPE program estimates poverty levels, i.e., numbers in poverty, rather than log-levels, log-ratios or log-odds ratios, we convert all model predictions into levels.[4] Converting to levels also makes results more comparable across models.

As discussed in Section 4.2, there is a strong average relation between the FRPL data and the Census 2000 poverty data. However, for the majority of districts, the fitted values from the regressions on FRPL data are far higher or far lower than the direct Census 2000 estimates. The large observed gaps between model predictions and actual values can be seen in *Figure 2*, which shows the ratio of model-predicted poverty to actual poverty (Census 2000 poverty estimates), from the log-odds ratios model, plotted against school-age child population at the school district level. Plots for the log-levels and log-ratios models (not shown) display a similar range of ratio values.

[4] To produce levels predictions from the log-levels model with z=log(y) as dependent variable, we compute exp(z). For the log-rates model with z=log(x/y) as dependent variable, we compute y*exp(z), and for log-odds ratio model with z=log((x/y)/(1-(x/y))) as dependent variable, we compute y*(exp(z)/(1+exp(z))).

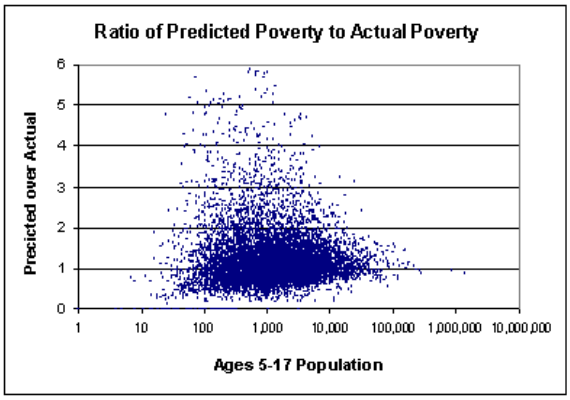

Figure 2: Model-predicted poverty divided by actual poverty (Census 2000 poverty) from the log-odds ratios model. The x-axis is ages 5-17 population from Census 2000 plotted in log scale and labeled in linear scale.

The plot shows the model predictions are frequently as large as three times, or as small as one-half the size of the Census 2000 poverty estimates. In order to summarize this dispersion of extreme model predictions, we compute the *median absolute percent error (MAPE)* between model predictions of poverty and the actual Census 2000 poverty data as follows:

Median absolute percent error (MAPE) =

$$\text{Median}\left(\text{Abs}\left(\frac{\text{Predicted Census 2000 Poverty}}{\text{Actual Census 2000 Poverty}}-1\right)\right)$$

The MAPE is computed using all districts in the regression, then using only the 500 districts with the smallest absolute prediction error (APE) and then using only the 500 districts with the largest APE. The latter two computations serve as benchmarks for best- and worst-case scenarios regarding the accuracy of the FRPL-driven model predictions of poverty. Our computations follow in *Table 3* below.

	for all districts	***lowest 500***	***highest 500***
Log Levels	32.3%	1.13%	397%
Log Ratios	31.6%	1.06%	327%
Log-Odds Ratios	31.5%	1.01%	302%
Log-Odds with Random Intercepts	29.5%	1.02%	290%

Table 3: Median absolute percent error between model prediction and actual values; median for the 500 school districts with smallest prediction error; and median for the 500 school districts with largest prediction error.

As shown in the leftmost column, the MAPE of all school districts is 32.3 percent for the log-levels model, 31.6 percent for the log-ratios model and 31.5

percent for the log-odds ratios model. Thus, the overall quality of model predictions is nearly the same for the three models. The random intercepts specification of the log-odds ratio model has a MAPE of all school districts of 29.5, or about 30 percent. We consider this model our base case for estimation.

The MAPE of 30 percent means that half the school districts tested have an APE greater than 30 percent, and the other half of districts tested have a lower APE. The gap between poverty predicted by FRPL and Census 2000 poverty for the typical school district is, therefore, fairly large. To put the observed variation in perspective, consider, for example, a school district with 1,000 children in poverty. The 30 percent MAPE implies that half of the time, the FRPL data would have a prediction of poverty that is less than 769 children or greater than 1,300 children. In the worst-case scenarios (right column of Table 3), these predicted versus actual gaps can be as large as a factor of 3.9, which would correspond to a range of between 256 and 3,900 children estimated in poverty.

Another way to see the dispersion in the estimates is through a sorted plot of APE, shown in *Figure 3* below, for the log-odds ratios with random intercepts model. Note that the vertical axis, APE, is in log scale (base 10), and the horizontal axis has the sorted school districts from 1 to 11,184 (sorted by APE).

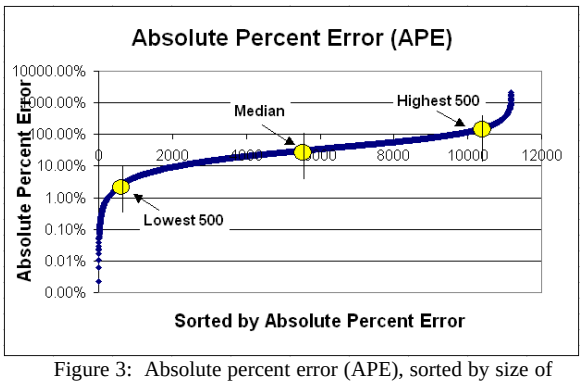

Figure 3: Absolute percent error (APE), sorted by size of absolute percent error (APE) for each school district.

At the center of the figure is the MAPE of 29.5%, roughly 30%, from Table 3. The tightest predictions are at the bottom left of the figure, and the most inaccurate predictions are at the top right. The median of all points to the left of the lowest-500 point is 1.02% (from Table 3), and the median of all points to the right of the highest-500 point is 290% (from Table 3). While there are many good model predictions, there are also many extreme model predictions.

Although the models tested show a strong summary relationship between 1999 FRPL counts and Census 2000 poverty estimates, thousands of school districts have model predicted values that are substantially different from the Census 2000 poverty estimates. Currently, the correspondence between the FRPL data and the poverty data is not sufficient for the FRPL data to provide reliable school district estimates. The benefit in accuracy for some districts may not outweigh the loss in accuracy in other districts. Since we find the association to be diffuse in the year of the decennial census, we are currently not taking the next step of extrapolating this association to intercensal years in producing official estimates.

5. Conclusion

There is information in free and reduced-price lunch (FRPL) eligibility counts that could be useful for estimating school district level poverty. In this research we have explored the possibility of supplementing SAIPE school district poverty estimates with FRPL eligibility counts. We noted, first, several difficulties related to the FRPL data, such as missing or incomplete data for over 2,000 school districts. Cognizant of these FRPL data limitations, we have run statistical tests on the available FRPL data in order to assess their predictive power for estimating poverty.

Our tests show a significant positive association between school district FRPL counts and Census 2000 child poverty estimates that is robust to various transformations of these variables. However, the poverty predictions from these regressions are imprecise, with a median absolute prediction error (MAPE) of 30 percent. These margins may be too large for the FRPL data to be helpful in estimating poverty, especially for the SAIPE program's estimates, which are used by the Department of Education and other entities in making funding allocations.

This analysis does not support the use of FRPL data for estimating school-age children in poverty at this time. FRPL counts and poverty estimates measure different concepts due to the use of different income cutoffs (130% and 185% for FRPL as opposed to 100% for poverty), the use of different income periods (monthly for FRPL and annual for poverty), differences between school district enrollment and school district population, and varying FRPL program awareness across districts. The data collection of FRPL may improve, which could merit further research and evaluation. Still, there are fundamental conceptual differences between FRPL participation and poverty status.

Other related research on school district estimates continues underway. Maples and Bell (2005) discusses the use of aggregated federal tax information, available for many school districts, in order to update the sub-county distribution of poverty annually. This approach faces other data reliability issues since not all tax return addresses can be assigned to small geographical areas and since filing and home addresses do not always match. A second potential approach involves fitting school district level models with school district poverty estimates directly as opposed to applying the synthetic shares approach. Although school district survey data from the CPS ASEC have been limited, school district survey data from the American Community Survey will be available in the coming years, and these data may be more suitable for modeling poverty.

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