Poverty and Algebra Performance: A Comparative Spatial Analysis of a Border South State

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This research uses two measures of poverty, as well as mobility and selected education variables to study how their relationships vary across 543 Missouri high school districts. Using Missouri and U.S. Census American Community Survey (ACS) data, local $R^2$'s from geographically weighted regressions are spatially mapped to demonstrate differences in relationships between poverty, mobility, and educational variables across districts. Results show the importance of allowing relationships to “vary” between districts and that using a global measure fails to capture important local contextual variation. Missouri and ACS poverty measures are related to each other and to selected education variables, but the strength of relationship varies significantly by regions across the state. The implications for future research and policy are discussed.

In Whither Opportunity? Rising Inequality, Schools, and Children’s Life Chances, Duncan and Murnane (2011) posited that the quality of education depends on spatial context, where growing concentrations of affluence and poverty and their related effects represent an important problem space. Their argument is a cautionary tale of the seemingly entrenched cycle of educational inequality and limited mobility experienced by disadvantaged groups living in poverty. In addition, Duncan and Murnane argued that economic segregation makes educational inequality less visible to the affluent and to society, thus reducing both a sense of common purpose and the level of civic engagement required to address the problem. Moreover, they challenge social scientists to engage in research that offers greater visibility to and understanding of the relationship between poverty, spatial location, and school outcomes. Spatial location refers to the relative position and distance of things in the context of neighborhood, community, region, or state.

Geographic factors associated with spatial location including neighborhood effects or regional effects have been understudied in the prominent paradigm of individual-level analysis of narrowly defined academic achievement (Tate & Hogrebe, 2011). The individualistic view is not framed to account for the influence of relational, organizational, and collective actions that influence the social formation of the demography of schools and related outcomes. Included among these processes and actions are factors that affect mobility and opportunity: government policies concerning taxation, service, investment, and redistribution; distribution of quality schools;
patterns of racial segregation; and social isolation in highly concentrated poor communities. Massey (2009) argued that the resurgence of class separation spatially corresponds with a growing income divide between the poor and the rich. This transformation is impacting children. In 2011, 12% of children were living in high-poverty areas nationwide, a total of 8.6 million (Annie E. Casey Foundation, 2013). These figures are reflective of a growth pattern since 2000, when the rate was 9%, with 2.3 million fewer youth living in concentrated poverty.

Consistent with the theme of this issue of the *Peabody Journal of Education*, the purpose of this article is to examine relationships between poverty and education in the state of Missouri using new approaches. More specifically, the aim is to offer insight into how race, poverty, and place influence algebra outcomes in a border south state. The research uses two measures of poverty and selected education variables to study how these variables are related across Missouri high school districts. The assumption guiding the research is that “place” or local context matters in determining the degree to which variables are related. School districts are comprised of different local contexts that vary in educational, social, cultural, political, and financial resources. It is important to show how relationships vary between local contexts and that one “global” measure of relationships may disguise significant local variation. The approaches used to demonstrate how the relationships between poverty and educational variables differ across school districts are geographically weighted regression (GWR) and spatial mapping. When compared to the ordinary least squares (OLS) global measure approach to studying variable relationships, GWR and spatial mapping both quantify and visually display the extent to which local contexts affect these relationships.

The focus of this research is on poverty defined in two ways: (a) percent participation in the free or reduced-price lunch program by district, and (b) percentage of students in the districts at or below 185% of the federal poverty level according to the U.S. Census American Community Survey (ACS; U.S. Census Bureau, 2006–2010). The study examines the relationship between these two measures of poverty at the school-district level using Missouri high school districts. The education variables selected to represent the relationship to poverty are mobility, attendance, dropout, graduation, and state end-of-course test scores in high school Algebra I. All of these indicators are a part of the state’s school accountability system.

The review of literature that follows illustrates the centrality of examining the influence of poverty on mathematics education outcomes in a southern state. Several analytical and measurement challenges associated with research focused on questions involving the influence of place and poverty on educational outcomes are highlighted.

**BACKGROUND LITERATURE**

**The Border South**

In this article, we classify Missouri as a southern state for purposes of the analysis. Prior to the Missouri Compromise of 1820, tensions were on the rise between proslavery and antislavery factions within the Congress and across the United States (Foner & Garraty, 1991). The political

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1 Children living in high-poverty areas is defined as the percentage of youth under age 18 who reside in census tracts where the poverty rate of the total population is at least 30%.
tension reached new heights with Missouri’s 1819 petition for admission to the Union as a slave state, which endangered the fragile balance between free states and slave states. To maintain the balance, Congress developed a two-part compromise, agreeing to Missouri’s petition to enter the Union as a slave state but also recognizing Maine as a free state. In addition, slavery was not to be permitted in any state later granted admission to the Union from lands associated with the Louisiana Purchase north of the southern boundary of Missouri. The South in the United States is commonly linked to states that seceded from the Union during the Civil War. Morris and Monroe (2009) argued that by protecting the right to continue racial slavery in the United States, states such as Missouri better reflect the historical South. Although not included in the sixteen states classified as southern states by the U.S. Census, Missouri is often viewed as “border South.” The state maintained a Confederate government in exile during the Civil War. Missouri’s origin and role as a political boundary situate it as a part of the history of the South.

Demographically, Missourian’s roots reside outside the state. Kirkendall (1986) described the influence of white migrants from the South, most notably in Little Dixie, an area in northeast and central Missouri, and west of Little Dixie along the Missouri River to Jackson County, stating, “many identified with the southern way of life and celebrated Confederate holidays” (p. 10). In addition, Tennesseans of both Confederate and anti-Confederate sentiments formed large portions of the populations of the Ozarks and the Bootheel. In terms of the Black population by 1910, Missouri was the only U.S. state outside of the census classification of southern state to have more than a 5% Black population. The percentage of Blacks in Missouri was larger than northern states but significantly smaller than other former slave states of the South.

Historically, Missouri has held bellwether status in politics and on hot-button social issues. The state’s location and demographics are cited as the cause for this status. In addition, from 1904 to 2004, the state of Missouri’s presidential voting aligned almost perfectly with the winning outcome of U.S. presidential elections. Another potential bellwether indicator of interest for this study is poverty. In 2011, the challenges associated with poverty continued for educators as 23% of children in the United States lived in poverty (Annie E. Casey Foundation, 2013). We focus on Missouri, where the percentage of children living in poverty mirrored the national average. Likewise, in 2011, the percentage of children living in families where no parent has full-time, year-round employment—32%—was the same in the United States and Missouri. With this as background, our study takes poverty and its effects on development and education into account while investigating the state of Missouri.

Poverty and Concentration Effects

The negative effects of poverty are experienced in rural areas and metropolitan regions (Farrigan & Parker, 2012; Wilson, 2009). Patterns associated with childhood poverty when coupled with concentration effects are central to young persons’ development and learning. Neuroscientists report that brain development is negatively altered by the environmental conditions associated with living in poverty (Farah et al., 2006). Children living in poverty demonstrated slower trajectories of brain growth (Hanson et al., 2013). Volumetric differences were related to the emergence of disruptive behavioral problems. Early human development, from the brain’s development to the child’s disposition, is affected by the environment and interactions that are experienced in a cumulative manner, starting at the prenatal stage and continuing into early childhood (Shonkoff &
Phillips, 2000). On the basis of this principle, Heckman (2006) argued that early learning confers value on acquired skills, which leads to a disposition to learn more. In addition, he posited that early command of a variety of cognitive, social, and emotional competencies supports more efficient learning at later ages. Arguing in a similar fashion, Darling-Hammond (2010) stated that a supporting pillar of injustice in the United States education system is the high degree of poverty and lack of social supports for children living in poverty, including health, welfare, and early learning opportunities.

Although poverty influences educational outcomes, one of the challenges in the literature examining the interrelationship of education and SES status is that simple explanations of how poverty combines with other factors or how it impacts differently across locations is scarce. There is evidence to support the position that concentration of disadvantage rather than disadvantage per se is more impactful in the relationship with educational outcomes and psychosocial outcomes (Galster, 2012; Sampson, 2012b). Examination of concentrated poverty-related disadvantage has not been widespread in education research. Nor are there many studies that have attempted to determine how poverty’s influence varies across district boundaries within a state (Hogrebe & Tate, 2012). This void in the literature is surprising given that the state is the primary authority in the governance of education and related implementation of school accountability. The metrics associated with school accountability are rarely examined to determine how poverty moderates their influence on student achievement while accounting for location. Although many studies have sought to estimate the influence of SES as measured by family income, parental occupation(s), and mother’s educational attainment on students’ achievement, there have been few inquiries seeking to report how poverty effects vary by geospatial location in a southern state with the intent to inform educational policy.

**Challenges and Analytical Opportunities**

The relationship between participation in the free or reduced-price lunch (FRL) program (U.S. Department of Agriculture, 2012) and education variables is frequently observed in studies that use FRL as a proxy for socioeconomic status (SES; Cruse & Powers, 2006; Harwell & LeBeau, 2010; Sirin, 2005). These researchers report inaccuracies in classifying which students enroll in the FRL program and suggest that FRL may not be a good proxy for SES, especially for individual students. Because participation in the FRL program is a dichotomous variable at the student level, it fails to capture the full definition and range of socioeconomic status.

If FRL is not a good estimate of SES at the individual level, could it be a reasonable estimate of poverty at the district level? Several studies addressed this question by examining the correlation of district FRL percentages with U.S. Census data that revealed inconsistent results (Cruse & Powers, 2006; Kurki, Boyle, & Aladjem, 2005). One major limitation of this research in the most recent studies is the use of outdated 2000 Census data. Also, it is difficult to convert Census data (which uses tracts and block groups as units) into school district boundaries. However, in recent years the School District Demographic System (National Center for Education Statistics, 2012) has used the ACS data, which is updated continually with ongoing census data (2006–2010) to estimate these variables within school districts. Current census data are now available to examine more accurately the relationship of poverty status to FRL across districts.
In the present study, the juxtaposition of the ACS data and the school district data offers the opportunity to examine the relationships of other variables. Our study will examine the relationship of poverty and mobility, which have been shown to be related to education variables (Pribesh & Downey, 1999; U.S. Government Accountability Office, 2010). Prior research suggests that poverty and mobility are related to variables such as attendance, dropout, and graduation, as well as academic performance, and that school location is important (Harwell & LeBeau, 2010; Sirin, 2005). These variables are indicators in Missouri’s school accountability system. The present study not only examines the overall relationship between these variables but, more important, looks at how the variables are related as a function of local context and the spatial clustering of districts. The focus on mathematics as an outcome measure has strategic importance in Missouri and for its residents.

Mathematics Education and Poverty

Over the past several decades, understanding the influence of poverty on mathematics achievement has been growing (Campbell & Silver, 1999; Hogrebe & Tate, 2012; Tate, 2008a). The prevailing methodological strategy has been to compare statistically mathematics assessment outcomes using SES categories. This is a standard practice in state accountability approaches to school mathematics. The information generated in these annual performance updates is published in newspaper accounts, rather than in scholarly publications. However, there are exceptions. For example, Jargowsky & El Komi, (2009) examined the relative effects of school and neighborhood factors on a criterion-reference test (Texas Assessment of Academic Skills) focused on mathematics and reading administered as part of the state’s accountability system.

School environments and school context are shaped by many factors, but clearly the characteristics of the families in neighborhood are a principal driving force. Even if neighborhood conditions are less robust than school context effects, concern about neighborhood conditions is still justified. Schools are largely formed as a geographic overlay on residential segregation. Reducing the concentration of poverty and economic segregation may be the easiest way to decrease the savage inequalities that exist between schools. Thus, we ought to be concerned about neighborhood effects on school achievement both by direct mechanisms and indirectly through their role shaping school environments. (Jargowsky & El Komi, 2009, p. 20)

Jargowsky and El Komi’s (2009) argument to attend to poverty, economic segregation, and achievement outcomes is rare in mathematics education; yet it links directly to the proposed study. Other scholarly traditions in mathematics education, while attending to SES, fall short of including geospatial consideration. For instance, another common methodological approach is to use a nationally representative sample of students surveyed in different time periods. In some cases, SES is a control variable. In other studies, the research design is constructed to estimate the influence of SES on mathematics achievement. However, rarely are there efforts to determine if poverty influences mathematics achievement differently by location. This limitation is not satisfactory in light of methods and tools that have the capability to inform policymakers with visual and statistical specificity about poverty effects in context.

Algebra is one branch of mathematics that provides an important problem space to study local context. The skills and understandings in Algebra I are a part of the gateway knowledge
associated with more advanced mathematics and science, college readiness, and postsecondary vocational opportunities (ACT, 2006; Smith, 1996). The Algebra I course in high school is a place to formalize and to extend the mathematics that students have learned in early grades (National Research Council, 1998). The skills and understandings associated with algebra appear throughout the elementary and secondary curriculum. Access and opportunity to learn algebra have been integral to discussions about equity in mathematics education (Moses & Cobb, 2001). In part to address equity and to promote opportunity, a large majority of state graduation requirements have mandated at least Algebra I for all secondary students. Yet, the opportunity to learn algebra is a challenge. Despite state Algebra I mandates, Hill and Dalton (2013) estimated that low-achieving ninth graders, and ninth graders overall, are more likely to have math teachers without a major in math than prior national results have suggested. Specifically, one in ten ninth-graders have math teachers with neither a math major nor math certification. This finding is uniquely significant given the critical importance of Algebra I, which is typically offered in ninth grade. The study does not provide information about poverty or geospatial location.

In order to address the lack of attention to the role of location, our study estimates how the relationships between Algebra I end-of-course (EOC) performance and education variables associated with neighborhood SES differ across school districts in the state of Missouri. Typically, education research and social science have endeavored to determine variable relationships in samples that represent “true” relationships in the overall population. Unfortunately, as a result of the complexity and variety of many local contexts in terms of educational, social, cultural, political, financial, infrastructure, and housing factors (among others), it is, at best, extremely difficult to specify adequately a model for variable relationships that is applicable across all SES contexts. Scholars now acknowledge that “place matters” (Dreier, Mollenkopf, & Swanstrom, 2014; Moretti, 2012; Orfield, 2002; Sampson, 2012a; Soja, 2010; Tate, 2008a), and it is crucial to account for location in examining variable relationships.

Purpose of the Present Study

The following research questions are examined with a single, global measure of variable relationships and then with geographically weighted regression (GWR) and spatial mapping using a geographic information system (GIS) to see how the relationships vary by districts within Missouri.

- What is the relationship between the poverty measures of the percentage of students at less than 185% of the federal poverty level (ACS; U.S. Census Bureau, 2006–2010) with the free or reduced-price lunch (FRL) percentage?
- What is the relationship between poverty and mobility as measured with district variables and with ACS variables?
- What is the relationship between district school mobility and ACS residential mobility?
- What is the relationship between FRL percentage with attendance rate and dropout and graduation percentages? Between FRL and state end-of-course scores in high school Algebra I?
When compared to the ordinary least squares (OLS) single measure of variable relationships, does the method of GWR more accurately quantify how specific contexts affect relationships and variation by location?

DATA SOURCE AND VARIABLES

The data for this study consist of 543 school districts in the state of Missouri in 2009–2010. There were 461 unified school districts and 82 elementary districts. All variables are aggregated to the district level, which is assumed to approximate a reasonably homogeneous local context. Furthermore, variable relationships are assumed to change on a continuum that is unrestrained by district boundaries.

The source of district data was the Missouri Department of Elementary and Secondary Education (DESE; Missouri DESE, 2010). The ACS (U.S. Census Bureau, 2006–2010) data was retrieved via the NCES School District Demographic System (2012).

Variables

The ACS poverty and residential mobility variables are reported at the school-district level as retrieved from the NCES School District Demographic System. The free or reduced-price lunch and school mobility variables as well as the other education variables are aggregated at the school-district level as reported by DESE.

Poverty

*Free or reduced-price lunch percentage (FRL)*. Percentage of students who received free or reduced-price lunches as reported by the school district. Students must be at 130% of poverty level to receive free lunches and at 185% to receive reduced-price lunches.

*American Community Survey 2006–2010 poverty*. Estimated percentage of students at less than 185% of poverty level within each district.

Mobility

*District school mobility rate for the academic year*. This is the number of students who transfer into the school district added to the number who transfer out of the district, divided by the total enrollment. This rate is an average of mobility for schools within the district.

*American Community Survey 2006–2010 mobility rate*. Number of school-aged children who were not in the same home one year ago divided by total number of children in the district. This indicates residential mobility.
Education

Attendance rate. Total hours in attendance divided by total hours enrolled in the school year.

Dropout rate. For grades 9–12 the number of dropouts divided by the total of September enrollment, plus transfers in, minus transfers out, minus dropouts, added to September enrollment, then divided by two. [Number of Dropouts ÷ ((Total September Enrollment + (Transfers In – Transfers Out – Dropouts)) ÷ 2)].

Graduation percentage. Number of students that graduate divided by the total number of grade 12 students enrolled all year.

Algebra I MAP index score. State of Missouri end-of-course scaled score.

METHOD

In order to determine if the relationships between poverty, mobility, and education variables differed across districts, relationships were tested using geographically weighted regression (GWR). Subsequently, the local regression $R^2$ coefficients from the GWR were given spatial perspective by mapping them with ArcGIS 10.1 (ESRI, 2012). ArcGIS is geographic information system (GIS) software that integrates spatial data (e.g., geo-referenced coordinates such as latitude and longitude) and nonspatial data to produce geographic maps.

GWR is designed to account for spatial dependence in clustered data and for the possibility that variable relationships may differ by location. Geographically clustered data represents an inherently continuous spatial process that the GWR procedure models using maps. This variation in relationships by location is referred to as “spatial heterogeneity” or “nonstationarity,” and GWR is able to incorporate these local spatial relationships in the analysis approach (Fotheringham, 2009; Fotheringham, Brunsdon, & Charlton, 2002). In contrast to multilevel models, the coefficients in GWR are not assumed to be random, but instead are directly related to their spatial location through corresponding geographic weights (Fotheringham et al., 2002, p. 52).

Data points are weighted by GWR according to their proximity to a specific location using a spatial kerning process (see Figure 1). Because data points vary by location they are not weighted equally across observations. Data points proximal to a specific location are assigned greater weights than points farther away. Using location as the basis for producing spatial weights, GWR calculates an optimum number of “nearest neighbors,” which are used to derive a local regression model for each geographic unit. In this study, GWR computed a local regression equation for each district based on the data from the district and the group of its nearest neighbors (Fotheringham, 2009; Fotheringham et al., 2002; Hogrebe & Tate, 2012).

The standard regression equation is modified in GWR to include geographic weights $(u_i, v_i)$ that represent the coordinates of the $i$th point in space. The weights signify the distance of each data point to the location of $i$ so that points closer have more weight in the parameter estimation for location $i$ (Fotheringham et al., 2002, p. 52). The standard regression equation can be rewritten for GWR using geographic weights $(u_i, v_i)$ as follows:

$$y_i = \beta_0 (u_i, v_i) + \beta_1 (u_i, v_i) x_{i1} + \beta_k (u_i, v_i) x_{ik} + \epsilon_i$$

In the present study, school district polygons were the data points and unit of analysis. A local regression equation was computed in GWR for each district based on the data from the district.
and the group of its nearest neighbors (Fotheringham, 2009; Fotheringham et al., 2002). An adaptive spatial kerning process was used in which the size of the kernel changed as a function of the density or number of districts in an area. For example, a high number of geographically smaller districts around the target district resulted in a smaller kernel size. The best fitting local regression equation for each district was created through this adaptive spatial kerning process. The optimal number of nearest neighbors for each kernel was determined by using the Akaike Information Criterion (AIC).

Each relationship between two variables was calculated separately using GWR. The results produced local regression $R^2$ values for each district and are mapped with GIS to show variation across the state. Ordinary least square (OLS) results are also reported to show the improvement in model fit using GWR. The statistically significant beta coefficients for the local regression $R^2$ values are mapped to indicate the direction and strength of the relationships. The family-wise Type I error rate for multiple, statistical tests of 543 beta coefficients was controlled by using the Benjamini-Hochberg procedure (Thissen, Steinberg, & Kuang, 2002) instead of the overly conservative Bonferroni technique.

Missouri unified school districts have both elementary and secondary schools, but there are 82 elementary-only districts. In order to deal with missing secondary data in the elementary districts and account for the underlying spatial continuum of secondary students who still live there, areal interpolation (ArcGIS 10.1) was used to estimate values for the elementary districts based on data in the surrounding unified districts. Since secondary students who live in the elementary districts attend secondary school in one of the neighboring unified districts, it is reasonable to use an
### TABLE 1
GWR and OLS Results Variables Relationships

<table>
<thead>
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<th>Category</th>
<th>GWR Results</th>
<th>OLS Results</th>
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</thead>
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<td>Adjusted $R^2$</td>
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<td>Mobility measures</td>
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<td>ACS residential mobility &amp; school mobility</td>
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<td>.130</td>
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<tr>
<td>School district measures</td>
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<td>FRL &amp; dropout rate</td>
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<td>FRL &amp; Algebra 1 exam</td>
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<td>.137</td>
</tr>
</tbody>
</table>

$aR^2$ for all districts computed from observed and GWR predicted values at each location that gives a measure of model fit.

$b$Lower Akaike Information Criterion (AIC) values reflect better fitting models.

$^c$Optimum number of “nearest neighbors” that were used to derive the GWR local regression model for each district from a total of 543 districts.

$dR^2$ for ordinary least squares (OLS) solution using all districts.

ACS poverty pct: American Community Survey 2006–2010 estimated percentage of students at less than 185% of poverty level in the school district.

FRL pct: Percentage of students who received free or reduced-price lunches as reported by the school district.

DESE mobility: District mobility from Missouri Department of Elementary and Secondary Education (DESE) that represents movement in and out of schools in the district.


EOC exam: DESE high-stakes end-of-course exam.

average of neighboring unified districts secondary school values as estimates for the elementary districts in order to maintain the continuum in geographic space.

**RESULTS**

Table 1 lists the global (overall) $R^2$ values for the relationship between the variables for all districts as well as the adjusted $R^2$ values, which show the expected $R^2$ shrinkage. The overall $R^2$ value for each variable is conceptually the squared correlation between the observed district values and the predicted values based on the local models. This overall $R^2$ value provides an indication of model fit along with the Akaike Information Criterion (AIC). Variables with lower AIC values are better fitting models and tend to reflect the higher $R^2$ values. The $R^2$ values range from a high of 0.660 for the relationship between district ACS poverty and FRL percent to a low of 0.161 for ACS residential mobility and DESE district school mobility. For every variable pair, the GWR $R^2$ values were higher than the OLS $R^2$ values and in most cases substantially higher, indicating
that variable relationships differ by location. Figure 2 transforms Table 1 data into a bar chart comparing GWR and OLS $R^2$ results.

The approach of reporting only the global $R^2$ values is limited in that it fails to show the substantial heterogeneity in variable relationships across districts within the state. However, since GWR computes local $R^2$ values for each district based upon its group of “nearest neighbor” districts, these local $R^2$ values can be mapped to represent the relationships spatially. The results of the GWR analyses were mapped using GIS to demonstrate how the relationships between the poverty, mobility, and education variables differed across districts throughout the state of Missouri. Figures 3a through 10b show two maps for each variable pair. The first map in the pair displays the local $R^2$ values, which show clearly that variable relationships can be quite different across districts and reflect a variety of local contexts and influences. The second map divides the $t$ test values for the beta coefficients into significant and nonsignificant categories at alpha .05 corrected by the Benjamini-Hochberg procedure discussed earlier.

Below is a summary of the four initial research questions:

- The relationship between the poverty measures of the percentage of students at less than 185% of the federal poverty level (ACS) with the FRL percentage is very strong, especially when local context is taken into account. The global $R^2$ value from the GWR analysis was .66 or correlation of $r = .81$. Figure 3a shows how the relationship varies across districts in
In terms of local $R^2$ values, which are much higher around the larger urban areas of St. Louis, Kansas City, Columbia, and Springfield. Figure 3b shows where the local $R^2$ values are statistically significant after controlling for multiple tests.

- The relationship between poverty and mobility as measured by the DESE district variables of FRL percent and school mobility was moderately strong (GWR global $R^2$ value = .399, see Figures 4a and 4b). Likewise, there was a significant relationship between ACS poverty and residential mobility variables for districts (GWR global $R^2$ value = .395, see Figures 5a and 5b). Although the relationships suggest higher poverty is associated with greater mobility, the GWR results showed that both of these relationships varied across districts and their local contexts (Figures 4a through 5b).

- There was a weak to moderate relationship between district school mobility and ACS residential mobility (GWR global $R^2$ value = .161). Districts that have high mobility in schools tend to have higher residential mobility; however, the strength of this relationship is very dependent upon local context and limited to the northwest and southeast districts in the state (see Figures 6a and 6b).

- The GWR global $R^2$ values were moderately strong for FRL percentage with attendance rate (.348, see Figure 7a), with the statistically significant local $R^2$ values forming a corridor connecting the two major urban areas along with another region in the bootheel (see Figure 7b). The GWR global $R^2$ values were moderately strong for FRL percentage with dropout rates (.325, see Figures 8a and 8b) and graduation rates (.265, see
FIGURE 3b Statistically significant beta coefficients for the relationship between ACS poverty and free or reduced-priced lunch percent in Missouri school districts. Multiple $t$ tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

FIGURE 4a Local $R^2$ values for the relationship between free or reduced-priced lunch percent and district school mobility in Missouri school districts.
FIGURE 4b  Statistically significant beta coefficients for the relationship between free or reduced-priced lunch percent and district school mobility in Missouri school districts. Multiple $t$ tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

FIGURE 5a  Local $R^2$ values for the relationship between ACS poverty and ACS residential mobility in Missouri school districts.
FIGURE 5b  Statistically significant beta coefficients for the relationship between ACS poverty and ACS residential mobility in Missouri school districts. Multiple t tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

FIGURE 6a  Local $R^2$ values for the relationship between ACS residential mobility and district school mobility in Missouri school districts.
FIGURE 6b  Statistically significant beta coefficients for the relationship between ACS residential mobility and district school mobility in Missouri school districts. Multiple t tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

FIGURE 7a  Local $R^2$ values for the relationship between free or reduced-priced lunch percent and attendance rate in Missouri school districts.
Statistically significant beta coefficients for the relationship between free or reduced-priced lunch percent and attendance rate in Missouri school districts. Multiple $t$ tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

Local $R^2$ values for the relationship between free or reduced-priced lunch percent and dropout rate in Missouri school districts.
FIGURE 8b Statistically significant beta coefficients for the relationship between free or reduced-priced lunch percent and dropout rate in Missouri school districts. Multiple $t$ tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

FIGURE 9a Local $R^2$ values for the relationship between free or reduced-priced lunch percent and graduation rate in Missouri school districts.
FIGURE 9b Statistically significant beta coefficients for the relationship between free or reduced-priced lunch percent and graduation rate in Missouri school districts. Multiple $t$ tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

Figures 9a and 9b). In contrast, the OLS $R^2$ values for these relationships were all less than .13, which indicates that they are impacted by local context.

- The relationship between FRL percentage and state standardized end-of-course scores in high school Algebra I was weak to moderate when allowed to vary by local context (GWR global $R^2$ value = .169, see Figure 10a). Districts that have a greater percentage of FRL students tend to have lower Algebra I scores; however, the strength of this relationship is very dependent upon local context and limited to the eastern and western districts in the state (see Figure 10b).

DISCUSSION

Historically, Missouri has been a bellwether state in politics and on social issues in the country. Although we make no claims that this study affirms Missouri’s bellwether status, the analysis offers a model of how other states associated with the U.S. South can determine if the relationships between poverty and education variables differ across school districts within their state. Our analysis of Missouri, a border south state, experiencing poverty levels similar to U.S. national averages is designed to take advantage of the NCES School District Demographic System that estimates ACS Census data within school district boundaries. Using this data set, we examined the relationships between census poverty and mobility variables with Missouri DESE school district poverty, mobility, and education variables. These variables are related, but the strength of the relationship varies widely across regions in the state. For example, the relationship of ACS
FIGURE 10a   Local $R^2$ values for the relationship between free or reduced-priced lunch percent and Algebra I scores in Missouri school districts.

FIGURE 10b   Statistically significant beta coefficients for the relationship between free-reduced priced lunch percent and Algebra I scores in Missouri school districts. Multiple $t$ tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).
poverty with FRL percentage tended to center on the large urban centers (larger local $R^2$ values) and spread out with diminishing local $R^2$ values (see Figure 3a). A somewhat similar pattern can be seen in the relationships between FRL percentage and attendance, dropout rate, graduation percentage, district mobility, and Algebra I scores. However, even within these relationships unique local contexts become visible. For instance, there is a significant relationship between FRL percentage and dropout rate in the rural Bootheel region in addition to the large urban areas of St. Louis and Kansas City (see Figure 8b).

This pattern of more statistically significant local $R^2$ values around the larger urban areas and fewer significant local $R^2$ values in the rural areas may be due to the greater variety of local contexts in the larger urban regions. The greater diversity of local contexts in the urban areas provides the opportunity for variable relationships to differ according to local policies and other factors unique to each location. In contrast, rural areas tend to cover larger geographic areas and may tend to be more homogeneous with fewer distinguishing local contexts.

It should be reiterated that these results are at the district level and may have implications for local or state policy; yet, they should not be projected to the individual level. For example, whether students are receiving FRL cannot be used to predict potential dropout or graduation for specific individuals. However, there are policy implications and research directions derived from this study. In Missouri, poverty is related to Algebra I outcomes. The relationship is stronger in rural and urban communities. Wilson and Howley (2012) posited that responsible scholarship focused on rural mathematics education must press beyond generic best practices and conventional wisdom imposed so widely on schooling. Instead, they argued for seeking alternatives that attend to local conditions. Similarly, urbanists focused on mathematics education have put forth arguments calling for interventions targeted to address the locally based state of affairs (Tate, 2008b; Tate, Jones, Thorne-Wallington, & Hogrebe, 2012). During the later part of the 20th century, the National Science Foundation and the Ford Foundation developed programs to attend to region-specific concerns in mathematics education. More recent policy responses to the urban and rural challenge in school mathematics have been driven by state accountability strategies. Our study used Missouri state accountability indicators, and the findings suggest the relationships between these indicators vary across the state. There is a need to test, evaluate, and generate evidence-based school mathematics practices consistent with the needs of local communities.

Mandated algebra coursework throughout the country is nearly inescapable. Yet, research estimates that college preparatory mathematics and science mandates are associated with school dropout (Plunk, Tate, Bierut, & Grucza, 2014). This suggests that Missouri, a border south state, and other southern states should support additional research on the potential school dropout effects that may be associated with mandating Algebra I and other coursework that build on the ideas of this subfield of school mathematics.

The relationship between poverty, mobility, and algebra performance in rural communities requires additional consideration. Specifically, attention to the intended and unintended consequences of mandated Algebra I coursework is warranted. In our study, higher poverty was associated with greater mobility in many rural communities. Historically, one challenge in rural communities has been the outmigration of young people as they complete their education. Outmigration can cost rural communities their most-educated residents and young families with a potential to contribute. This is connected to Algebra I outcomes because doing well in
mathematics is related to positive school performance, and thus, potentially the outmigration from rural areas. One intended consequence of mandating college preparatory mathematics is improved skills and understanding for traditionally underserved communities. However, an unintended effect might be further outmigration in rural communities due to a “brain drain” or human capital flight. In Missouri and other southern states, mandated Algebra I coursework suggests there is a need for more research on the relationship between poverty, mobility, and Algebra I outcomes.

When relationships are not seen as “stationary” but allowed to vary across location, the inadequacy of relying solely on a global measure becomes transparent because variable relationships depend on local context and are not the same everywhere. In terms of methodology, OLS models did not appropriately estimate the heterogeneity in variable relationships across school districts in Missouri. The bottom line is that “place matters” in moderating variable relationships because there are differences in regional factors related to social, cultural, political, and educational influences and resources. The results of this study demonstrate the need to take local context and geographic clustering into account when analyzing relationships between poverty and education variables. Because there will always be different local contexts, it will remain a difficult methodological task to find one global relationship measure for poverty and education variables that applies to every situation.

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