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ABSTRACT

A cornerstone of the Kentucky Education Reform Act of 1990 was the creation of a high-stakes performance assessment program called the Kentucky Instructional Results Information System (KIRIS). KIRIS test results were the basis for granting monetary rewards to schools and school districts where student test performance improved significantly and for levying sanctions where student performance declined. KIRIS was based on the belief that school districts and educators should be held accountable regardless of the advantaged or disadvantaged circumstances of their communities. In contrast, recent research suggests that socioeconomic factors associated with geographic location may strongly influence on school system performance and, therefore, on test results. Using data from 176 Kentucky school districts, this paper analyzes the spatial distribution of socioeconomic factors and educational outcomes. Data include 1992-96 mean accountability scores, which reflect district performance at grades 4, 8, and 12; rural-urban location; median household income; percentage of students on free or reduced-cost lunch; teen birth rate; independent versus county school district; per-student spending; and enrollment. Accountability scores were strongly and negatively influenced by percentage of free/reduced lunch and were positively influenced by rurality. Socioeconomic factors had a spatial distribution that was spatially autocorrelated; these factors increased in importance at higher grade levels. Policy recommendations are offered. (Contains 15 references.) (SV)

A SPATIAL ANALYSIS OF CONTEXTUAL EFFECTS ON EDUCATIONAL ACCOUNTABILITY IN KENTUCKY

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1. INTRODUCTION

A call to make public education more effective by making it more accountable has swept the nation during the 1990s (Federal Reserve Bank of New York 1998, Ladd 1996). Kentucky became one of the states that led this movement when its legislature passed the ambitious Kentucky Educational Reform Act of 1990 (Guskey 1994). A cornerstone of this reform initiative was the creation of a high-stakes performance assessment program, called the Kentucky Instructional Results Information System (KIRIS). The KIRIS test results were used as a basis for granting monetary rewards to school and school districts that showed significant improvement in student test performance and for levying sanctions against schools and districts where performance declined. The philosophy guiding the use of KIRIS was that all school systems in the state could effect steady and substantial improvement in KIRIS scores irrespective of the socioeconomic context in which the schools are found. In other words, the belief was maintained that school districts and educators should be held accountable regardless of the advantages or disadvantages with which their local communities presented them. Against this philosophy recent research has begun to suggest that, at least in the long if not in the short run, socioeconomic factors associated with geographic location may have a strong determining influence on school system performance and therefore on the accountability test results (Reeves 1998, Reeves 2000, Reeves and Grubb 1999).

At this time, the accountability movement has given little attention to how much socioeconomic context influences educational outcomes. Furthermore, there is almost no recognition in the research literature that socioeconomic factors are spatially distributed and thus can be subjected to geographic analysis. The purpose of this investigation is to show how such an analysis might be done using Kentucky accountability results.

2. THE SAMPLE AND MEASUREMENTS

The sample for this study consists of 176 Kentucky school districts. The measurements taken on each district consist of accountability index scores provided by the Kentucky Department of Education and various contextual influence measures derived from census reports and other sources.

2.1. THE DEPENDENT VARIABLE

For dependent variables, we used the 1992-96 mean accountability scores for each Kentucky school district, obtained from the Kentucky Department of Education (KDE). The accountability score is a weighted sum of the following components: reading (14%), mathematics (14%), science (14%), social studies (14%), arts and humanities (7%), practical living (7%), writing (14%), and noncognitive data (16%). The noncognitive data are compiled from student attendance, retention, dropout, and transition to adult life.

The scores reflect the district performance at the 4th, 8th, and 12th grades, as well as an overall composite score. The composite mean accountability scores ranged from 33.5 to 63.6 with an average of 41.9 and a standard deviation of 4.4. The 4th grade scores ranged from 31.1 to 63.6, averaged 41.9 and had a standard deviation of 5.2; 8th grade scores ranged from 30.6 to 61.1, averaged 41.5 and had a standard deviation of 4.9; and 12th grade scores ranged from 31.0 to 58.8, averaged 41.8 and had a standard deviation of 5.0.

2.2. CONTEXTUAL MAIN EFFECTS

To determine how rural-metro differences and other contextual effects would influence the high-stakes accountability scores, we devised the following independent variables:

2.2.1. Rural-Metro Differences

Khattri *et al.* (1997) have noted that it is still an open question if geographic location is as important a factor as poverty in contributing to educational outcomes. Of particular interest in this study is the combined effect of geographic location and population concentration on the accountability scores. We developed categorical variables expressing these rural-metro differences by recoding the 1993 Urban Influence Codes put out by the Economic Research Service of the U.S. Department of Agriculture. The Urban Influence Codes classify all U.S. counties into nine exclusive categories based on (1) the size of the Metropolitan Statistical Area (MSA) for metro counties and (2 categories) (2) adjacency to metro counties and size of the largest town for nonmetro counties (7 categories). We simplified this classification scheme, because Kentucky does not have any large metro counties and several of the metro-adjacent categories are either missing or little represented.

Our recoding of the Urban Influence Codes resulted in the following categories: Metro counties (*i.e.,* located in an MSA) became the reference category for the multivariate analysis. Twenty-four percent of the school districts in the sample are classified "metro". Nonmetro counties were of two broad types, either they were adjacent to a metropolitan county in which case they are referred to as "metro-adjacent" or they were not adjacent to a metropolitan county in which case they are referred to as "rural". Metro-adjacent districts comprise 25% of the Kentucky sample. The rural counties are subdivided into three discrete categories according to the size of the largest town or city. "Rural 1" refers to a rural county in which the largest town has a population less than 2,500. Seventeen percent of the school districts are in this category. "Rural 2" counties have a town with 2,500 to 9,999 inhabitants. Twenty-three percent of the school districts fall into this category. "Rural 3" is a category of rural counties in which the largest town has a population of 10,000 or more. This category contains eleven percent of the school districts.

2.2.2. District Median Household Income

Our measure of the SES level of the general population in the school district is the median household income. This information was acquired from the School District Data Book (National Center for Education Statistics) and is based on a special run of the 1990 U.S. Census data. For the present study, the median household income of the Kentucky school districts varied between $8,150 and $82,435 with a mean of $20,258 and a standard deviation of $7,581.

2.2.3. Percentage of Students on Free/Reduced Lunch

The mean percentage of students in the school district on the free or reduced-cost lunch program is the variable that we chose to measure student poverty. The measure was obtained by averaging KDE data for the 1989-90 and 1994-95 school years. This variable averages 44.9 for the entire state, with a standard deviation of 17.3. The mean percentages of students on free/reduced lunch vary from 2.3 to 89.1 percent.

2.2.4. Teen Birth Rate

Teen birth rate may be considered a proxy measure for the youth opportunity environment in the school district (Bickel *et al.* 1997) The teen birth rate is defined to be the number of births in a county per 1,000 females, aged 12 to 17 years. In this study, an average teen birth rate was calculated for each Kentucky county using 1992-94 data. We obtained these data from the 1995 Kentucky KIDS COUNT. Across the state of Kentucky, the average teen birth rate is 20.9 with a standard deviation of 6.33. The county with the lowest teen birth rate had an average of 6.4 while the county with the highest rate had an average of 39.0.

2.2.5. Independent School District

This variable, a dummy, denotes that the school district is one of 56 independent districts in Kentucky (32 percent of the total 176 districts). The independent districts tend to be smaller, wealthier, less rural, and higher performing on the accountability index than the county districts.

2.2.6. Per Student Spending

Although previous studies have found only a weak correlation between student performance and per student spending (*e.g.*, Hanushek 1997), we thought it prudent to incorporate a measure of per student spending by school district as a control variable, since metropolitan school districts are often better funded than their rural counterparts--a pattern in Kentucky that is also found nationwide (Stern 1994). This variable was constructed by averaging KDE data for two school years, 1989-90 and 1994-95. The resulting measure finds the average level of per student spending statewide is $4,377 with a standard deviation of $518, while the range in spending is between $3,584 and $7,994.

2.2.7. Enrollment

Some researchers have argued that large schools and large districts are detrimental to disadvantaged students (Friedkin and Necochea 1988). Therefore, we chose as a third control variable the average student enrollment by school district. To obtain this variable we used the KDE 1994-95 enrollment figures for each Kentucky school district. Across the state school district enrollment varies greatly, from a tiny independent school district in a metropolitan county that has only 208 students to a metro county district with an enrollment of 34,165 students. The mean enrollment statewide is 3,371 students with a standard deviation of 4,079.

2.3. INTERACTION EFFECTS

In addition to the above main effect variables, our regression model examined two types of interactions. In constructing these interaction terms, the continuous variables were centered on their means to reduce collinearity with the corresponding main effects.

2.3.1. Enrollment x Percent of Students on Free/Reduced Lunch

The first of the interaction terms was the bilinear interaction between enrollment and percentage of students on free/reduced lunch. We decided to test for this effect because Howley (1996) found that small district size has a beneficial moderating effect on the academic performance of low-SES students.

2.3.2. Rural-Metro Categories x Percent of Students on Free/Reduced Lunch

With the exception of studies by Alspaugh (1992) and Lippman *et al.* (1996) that focused on the rural-urban dichotomy, little research has been conducted on how geographic location moderates the effect of student poverty on educational outcomes. In the present study we have employed interaction terms to capture the combined effect of location and poverty. Four interaction terms were constructed to test for the effect of percent of students on free/reduced lunch when moderated by the different rural-metro categories. When assessing the interaction effects, the reference category is the interaction term, metro x % students on free/reduced lunch.

3. REGRESSION ANALYSIS

The regression analyses used in the present paper are based on Reeves and Grubb (1999). The regression models (see Table 1) present the standardized coefficients of the main effects and the interaction effects on the accountability score. In the composite model, the largest effect is the percent of students on free/reduced lunch. Median household income is not significant, while teen birth rate marginally approaches significance in this model. All three categories of ruralness are significantly positive when compared with the metro category. The model also tests the effects on the accountability score of the percent of students on free/reduced lunch when moderated by geographic location. The results of the interaction effects are significantly positive for all rural categories. Furthermore, the more rural the district the greater the strength of the interaction effect. Overall, the composite model predicts nearly 49 percent of the variance.

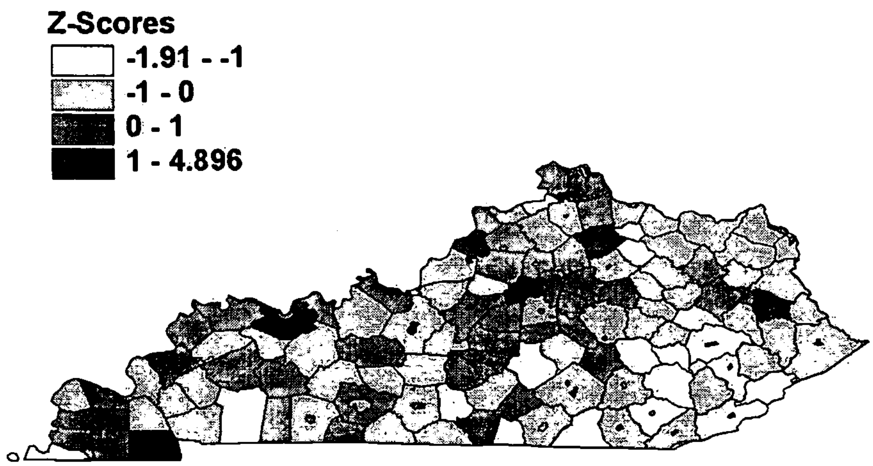
TABLE 1
STANDARDIZED OLS REGRESSION COEFFICIENTS FOR VARIABLES PREDICTING 1992-96 KENTUCKY SCHOOL DISTRICT ACCOUNTIBILITY SCORES BY GRADE LEVEL

Variables	*COMPOSITE*	*GRADE* 4	*GRADE* 8	*GRADE* 12
Median household income	.171	.101	.161	-.033
Percent free/reduced lunch	-.906**	-.668**	-.915**	-.819**
Teen birth rate	-.123~	-.009	-.163*	-.192**
Independent school district	.208**	-.051	.186*	.411**
Per student spending	.060	.159~	-.027	.010
Enrollment	.045	-.052	.096	.091
Enrollment X % free/reduced lunch	.057	.044	.051	.009
Rural 1: town < 2,500	.181~	-.015	.281**	.148
Rural 2: town 2,500-9,999	.338**	.169	.453**	.196*
Rural 3: town ≥ 10,000	.256**	.181~	.284**	.142~
Metro-adjacent	.216*	.113	.325**	.078
Rural 1 X % free/reduced lunch	.349**	.284*	.345**	.267*
Rural 2 X % free/reduced lunch	.202*	.140	.252**	.116
Rural 3 X % free/reduced lunch	.146*	.135	.144*	.093
Metro-adjacent X % free/reduced lunch	.165~	.121	.211*	.089
R^2	.532	.249	.471	.556
Adjusted R^2	.488	.179	.422	.513

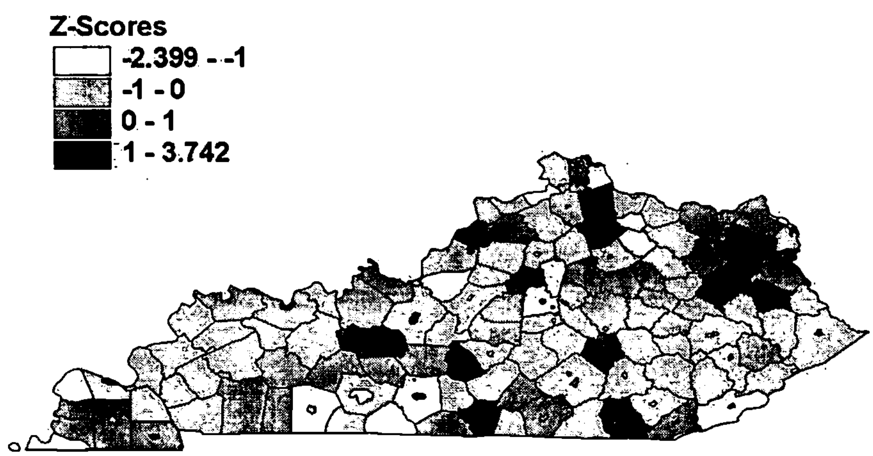
~$p < .10$; *$p < .05$; **$p < .01$. Note: For Composite, 4th and 8th grade models, $N = 176$; for 12th grade model, $N = 171$.

The grade-level models reveal a remarkable tendency. When the 4th and 8th grade models are compared, the predicted variance more than doubles with the higher grade level and increases again by 9 percent when the 8th and 12th grade models are compared. It should also be noted that teen birth rate has a significant negative effect on 8th and 12th grade scores but not on the scores of the 4th graders. Rural-metro differences are important at the 8th grade level but are comparatively less important at the 4th or 12th grades. Finally, independent school district has an especially strong, positive effect on 12th grade scores.

FIGURE 1
COMPOSITE SCORES BY SCHOOL DISTRICT, 1992-1996

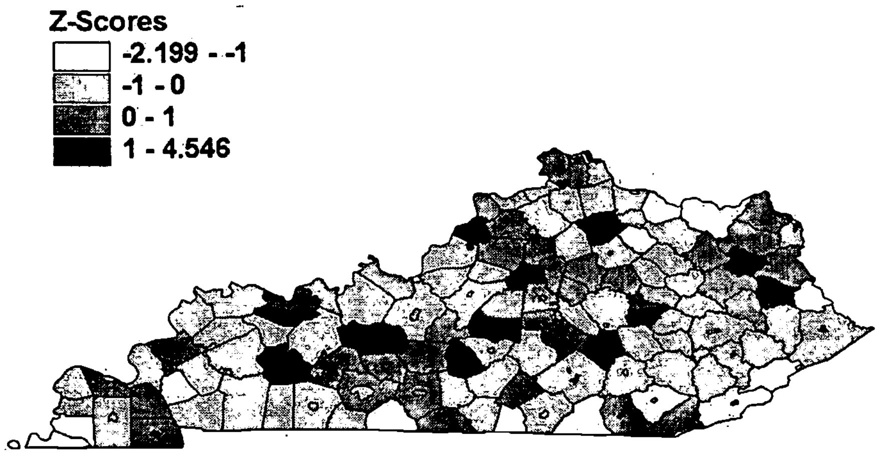


a) Standardized KIRIS Scores

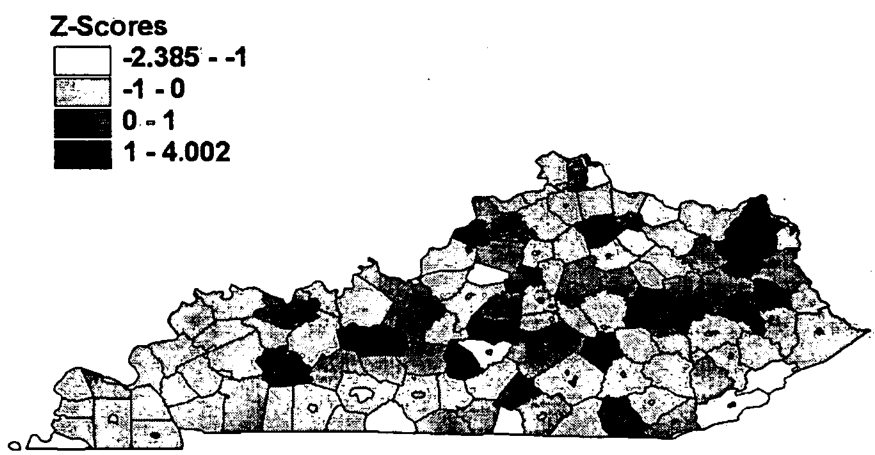


b) Standardized Residuals

FIGURE 2
GRADE 4 SCORES BY SCHOOL DISTRICT, 1992-1996

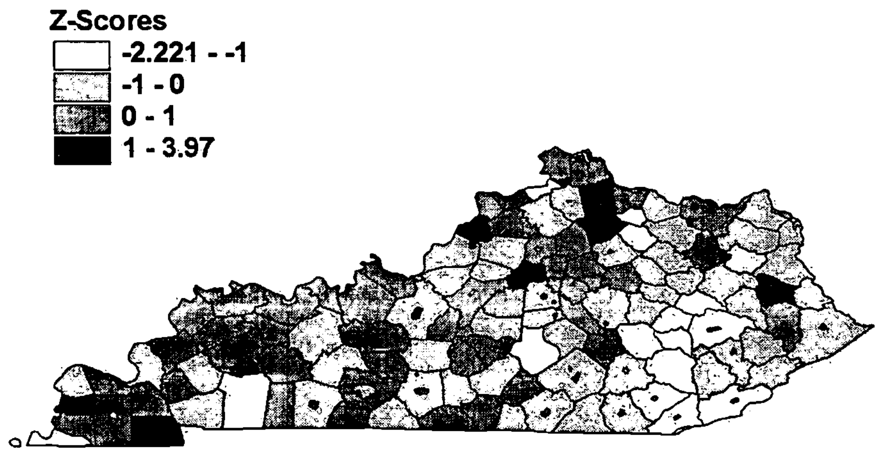


a) Standardized KIRIS Scores

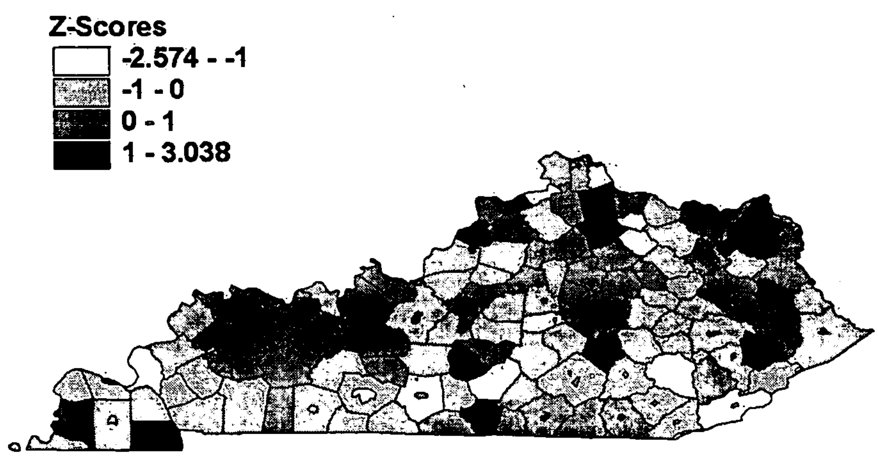


b) Standardized Residuals

FIGURE 3
GRADE 8 SCORES BY SCHOOL DISTRICT, 1992-1996

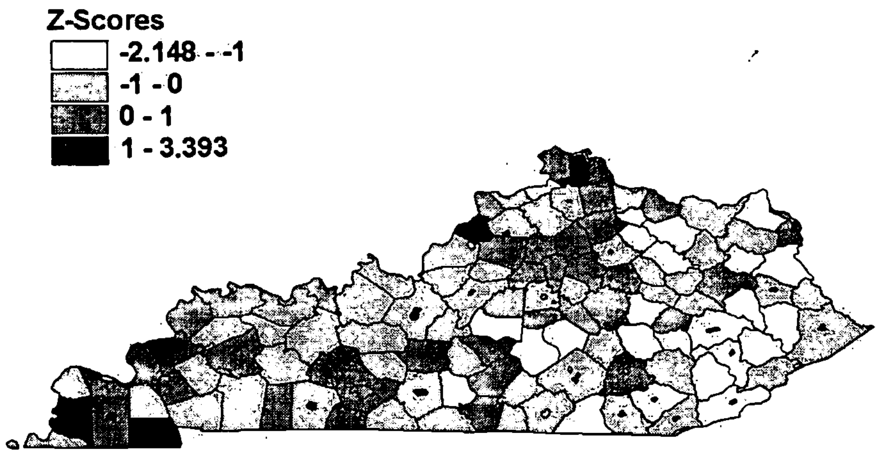


a) Standardized KIRIS Scores

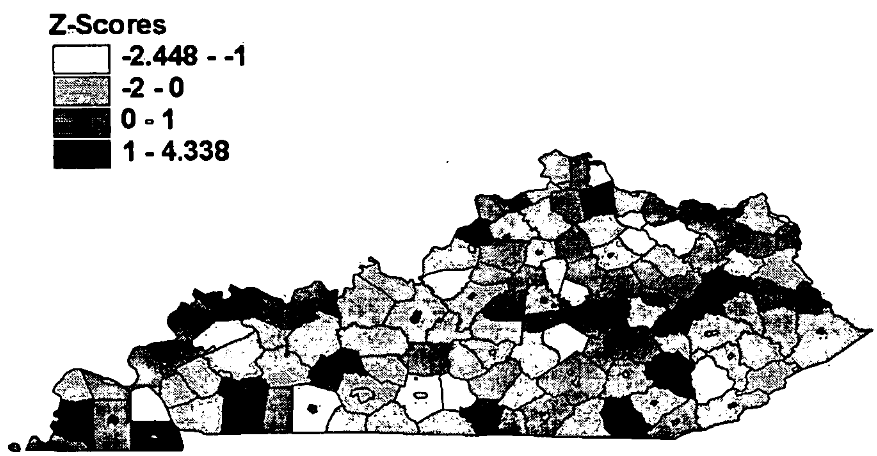


b) Standardized Residuals

FIGURE 4
GRADE 12 SCORES BY SCHOOL DISTRICT, 1992-1996



a) Standardized KIRIS Scores



b) Standardized Residuals

4. METHODS OF RESIDUAL ANALYSIS

In order to measure the amount of clustering in KIRIS scores, a measure of spatial autocorrelation is needed. One measure useful in determining the level of spatial autocorrelation in variables measured at the interval/ratio level is Moran's *I*-coefficient. Moran's *I* uses the form of the typical correlation coefficient but compares neighboring areal units (Griffith and Amrhein 1991). Since the current data are standardized scores, the mean is zero, simplifying the standard Moran formula to:

$$I = [n/(\Sigma_i\Sigma_j c_{ij})] [\Sigma_i\Sigma_j (z_i c_{ij} z_j)/\Sigma_i z_i^2] \qquad [1]$$

where, n = number of areal units;
c_{ij} = 1 if areal unit i is adjacent to areal unit j, 0 otherwise;
and z_i (z_j) = standardized score for areal unit i (j).

The results of Moran's *I* tend to range between -1 and 1 like the traditional correlation coefficient, though they are not limited to that range. More positive values indicate *positive* spatial autocorrelation in which similar values are clustered, more negative values indicate *negative* spatial autocorrelation in which dissimilar values are near each other spatially.

The expected value of Moran's *I* in a sample and standard error are (Griffith and Amrhein 1991):

$$E(I) = -[1 + n\, \Sigma_i\Sigma_j\, z_i\, c_{ij}\, z_j/(n-1)\Sigma_i\Sigma_j\, c_{ij}]/(n-2) \qquad [2]$$

$$s_I = (2/\Sigma_i\Sigma_j\, c_{ij})^{1/2} \qquad [3]$$

Figures 1-4 show the patterns of a) standardized KIRIS scores for Composite, Grade 4, Grade 8 and Grade 12, respectively, and b) standardized residuals for Composite, Grade 4, Grade 8 and Grade 12, respectively. Table 2 indicates the Moran's I, $E(I)$, σ_I, and z-value of the standardized KIRIS scores and of the standardized residuals of the model.

5. DISCUSSION

Table 2 indicates the value for Moran's *I* as calculated from the results presented graphically in Figures 1-4. The range for Moran's *I* is similar to that of the traditional correlation coefficient. Columns 2-5 represent the level of spatial autocorrelation of standardized KIRIS scores. Columns 6-9 represent the level of spatial autocorrelation of the standardized residuals when contextual effects are held constant at their mean value or at the reference category.

Figures 1-4 demonstrate the results in Table 2. For instance, in Figure 1a there is a cluster of poorly performing districts in the southeastern part of the state and a cluster of highly performing districts in the north central region. This represents a relatively high degree of spatial autocorrelation (I = 0.182). In Figure 1b, the large clusters are removed in large part, though some clusters of high residuals are created for instance in the northeast part of the state. This represents a moderate degree of spatial autocorrelation (I = 0.105). Figure 4 provides an even starker contrast. Figure 4a demonstrates a large cluster of poor performance in the eastern and southeastern portion of the state and clusters of high performance in the central and western portions ($I = 0.208$). Figure 4b illustrates no discernible clusters with the lowest level of spatial autocorrelation of all the distributions measured in this paper ($I = 0.062$).

TABLE 2
MEASURES OF SPATIAL AUTOCORRELATION

	KIRIS Scores				*Standardized Residuals*			
	Comp	Grade 4	Grade 8	Grade 12	Comp	Grade 4	Grade 8	Grade 12
I	0.182	0.087	0.178	0.208	0.105	0.070	0.080	0.062
E(I)	-0.007	-0.006	-0.007	-0.007	-0.006	-0.006	-0.006	-0.006
σ(I)	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
z	3.727	1.845	3.640	4.234	2.194	1.510	1.690	1.345

Several general results are obvious from the table and figures. First, in every case, the use of a regression model to account for variation in contextual effects helps to diminish the level of spatial autocorrelation in the residuals as compared to the uncorrected scores. Clearly, contextual effects are spatially autocorrelated, so most of the autocorrelation of the KIRIS scores is associated with autocorrelation of the contextual variables.

Second, the value of Moran's I of the residuals is consistent at a low score for all three of the grade-specific cases. In all three cases, it is not significant at the level of α=0.05. This suggests that the regression model helps to eliminate spatial autocorrelation in the KIRIS scores.

Third, for the KIRIS scores, as grade level increases, the level of spatial autocorrelation increases. This suggests that contextual effects are more important as grade level increases since the spatial autocorrelation can be removed by accounting for contextual effects in a regression model. Therefore, it seems that students become more influenced by the contextual effects of their communities as they get older.

6. CONCLUSIONS

From this analysis, it seems clear that contextual effects have an influence on educational outcome. In particular, this study has shown that socioeconomic factors have a spatial distribution that is spatially autocorrelated. Furthermore, it seems that the importance of these factors in student achievement increases with higher grade levels and thus is more influential for middle and high schools than for elementary schools.

Two policy prescriptions emerge from this analysis. First, socioeconomic factors should be factored into the assessment program for high schools and middle schools. The current uncorrected KIRIS scores overstate the performance of schools and districts in advantageous situations and understate the performance of schools and districts that are disadvantaged.

Second, the geographical context also needs to be taken into account. The current method of assessment ignores the spatial distribution of KIRIS scores. Neighboring districts have similar values that cannot be explained by district or school performance. If spatial autocorrelation is present in a dataset, a spatially varying explanatory variable has been left out of the analysis. When nearby districts seem to be performing similarly without any causal explanation as to how or why, the assessment is misleading.

This study underscores the importance of considering socioeconomic context and geographic effects when assessing schools. Further research into the role that spatial analysis can play in gaining a better understanding of educational performance is needed. In particular, the pattern of accountability scores at the school level would provide a needed refinement to the current research. Unfortunately, the areas from which individual schools draw students are constantly changing, making the collection of contextual data difficult.

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