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Spatial Processes in College Access: An Exploration of Wisconsin

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Introduction

States across the nation are striving to improve the educational attainment of their residents, since a secure economic future now requires a substantial college-educated population. But some states are struggling to meet this challenge, especially those in non-coastal regions where the loss of manufacturing jobs has meant declining wages and employment opportunities. For example, in Wisconsin, only 22 percent of the population ages 25 years and older has a bachelor's degree, below the national average of 24.4 percent (U.S. Census Bureau 2006).

While a state's stock of college-educated labor is often affected by factors such as the inflow and outflow of workers holding that degree, in Wisconsin part of the challenge lies in moving a greater percentage of high school graduates on to college. The college continuation rate has declined over time, and a large proportion of Wisconsin undergraduates are enrolled in two-year technical colleges that lack a 'transfer mission' and from which only a small proportion of students go on to a four-year school.

Efforts to improve college access in Wisconsin--as in many states--have thus far focused primarily on improving high school preparation and alleviating the financial burden on families. Analyses, such as those conducted by the University of Wisconsin System, often point to credit constraints among poor students and their lower ACT test scores when attempting to explain their lower rates of college-going. Yet, research finds residual differences in college-going among rich and poor students in the state, even after controlling for financial and preparation factors (CITES). In this paper, we conduct an exploratory spatial data analysis (ESDA) to investigate an additional potential process shaping college access, using the State of Wisconsin as an example. Specifically, we descriptively examine the possibility that the known contributors to college access--for example, household income, parental education, access to college-preparatory courses, and strong test scores--are organized in space in specific non-random patterns. If spatial patterning is found to exist, it may suggest additional important processes affecting college access rates in the state. Indeed, our evidence indicates that some traditional predictors of access do spatially 'cluster' in significant ways in Wisconsin. This creates the possibility that the spatial patterning of college access predictors may contribute to the observed distribution of access rates throughout the state. In future research, we will test this hypothesis by examining how the process of college enrollment varies across spatial regimes with more or less college disadvantage.

Higher Education in Wisconsin

There are three higher education sectors in Wisconsin: the University of Wisconsin System, the Wisconsin Technical College System, and the private colleges. All 13 public four-year colleges are part of the University of Wisconsin (UW) System, which also includes 13 public two-year colleges (once called "UW Centers", now known as the "UW Colleges"). Figure 1 illustrates the dispersion of those 26 campuses throughout the state. The System was formed between 1971 and 1974 via a merger of the University of Wisconsin, the Wisconsin State University, and the University of Wisconsin Center System. Apart from the UW System there are 16 public technical colleges, 34 private four-year colleges, and 2 private two-year colleges. Forty-four percent of Wisconsin's approximately 293,000 undergraduates are enrolled in UW's four-year colleges and universities. The public two-year colleges and the technical colleges enroll another 39 percent, leaving the private schools with only 17 percent of the undergraduate population.[2]

<<<Figure 1 here>>>

Wisconsin's two-year colleges differ in important ways from the community college systems present in most other states. The mission of the UW Colleges is explicit—to act as "freshmen/sophomore campuses" offering students the first two years of college, after which point they are expected to transfer to one of the four-year campuses. The UW Colleges began as part of extension services in 1907, and expanded through agreements with several county Normal schools beginning in the early 1930s. From the start the UW Colleges were targeted to serve students from rural areas that did not go away for college and thus "would not have started college if a Center (College) had not been available."[3] Since the UW Colleges are part of the UW System, they have a special articulation agreement (developed in 1987) which includes a low grade point average requirement (2.0) and guaranteed admission to one of the four-year campuses upon successful completion of the first two years.

[2] Figures are from Measuring Up 2006; we have not been able to locate similar numbers from another source which would break-down enrollment in UW Colleges vs. tech colleges.
[3] See www.wisconsin.edu/uwc-uwex/chancellorsearch/historyuwc.htm

In contrast, all but three of the Wisconsin technical colleges, which are governed by a separate entity, do not identify transfer as part of their mission. While some (most recently Madison Area Technical College) have begun to establish 'guaranteed admissions' agreements with specific UW four-year campuses, those agreements are idiosyncratic and require higher pre-university grades than the UW College agreements.[4] In addition, efforts to institute transfer agreements at technical colleges tend to encounter significant political opposition (CITE). Thus, access to the baccalaureate in Wisconsin is greatest for those students beginning at the UW four-year campuses, followed by students beginning at the UW Colleges.

There is a clear hierarchy in the UW System which places a strong emphasis on its flagship campus, the University of Wisconsin-Madison. Students throughout the state apply to Madison in large numbers, often seeking to not only attend the 'best' campus but also to live in the state capital. This hierarchy can be crudely assessed by examining where ACT test-takers send their scores. Among 134,000 Wisconsin ACT test-takers in 2006, the largest share of scores sent to any one campus—8 percent— was sent to UW-Madison, with 45 percent of those students indicating that Madison was their first choice school. UW-Milwaukee was a close second (7% of test-takers), but only one-third of students sending scores indicated it was their first choice. In sharp contrast, only 1.4 percent of 2006 test-takers had their scores sent to UW-River Falls, the least popular of the UW four-year campuses, and less than 1 percent of test-takers had their scores sent to UW-Waukesha, the most popular of the UW Colleges (ACT 2006). Additional evidence that students have a strong preference for attending UW-Madison can be found in the low take-up rate of the Connections Program, which offers promising students who are denied a place in Madison's freshmen class the opportunity to complete their first two years at a UW College or one of the three transfer-focused technical colleges and then transfer to Madison via a 'dual admissions' agreement.[5]

[4] It would be desirable to compare the transfer rates of students from UW Colleges and the technical colleges to the UW four-year campuses, but those rates are not currently available.
[5] Searching for data on take-up rate, former School of Education Dean Charles Read reported in a personal communication that it is quite low.

College Preparation in Wisconsin

The transition to college varies across states according to high school graduation rates, academic preparation for college, and college-going behaviors, among other factors. The extent to which a state and its school districts offer students opportunities for advanced course-taking and require them to achieve high standards has a significant impact on college enrollment rates (Achieve 2005). Thus, in the next section we describe the college-preparation opportunities available to public school students in Wisconsin.

Wisconsin's public education system is comprised of nearly 900,000 students attending approximately 2100 schools in 431 school districts. The school-age population is 81 percent white, one-fourth of students qualify for free- or reduced-price lunch, and 57 percent attend schools in rural districts. Seventy-eight percent of Wisconsin high school freshmen graduate with a diploma. But as in many states, graduation rates are significantly lower for male and minority students. Moreover, there is substantial variation in graduation rates across the ten largest school districts, ranging from a low of 45.8 percent in Milwaukee (the state's largest city, with an enrollment of 97,985 and an 81% minority population) to a high of 90.9 percent in Appleton (enrollment= 14,793, 14.7% minority) (Swanson 2004).

The State of Wisconsin has a single diploma system, granting only one type of diploma. The minimum 12.5 credit requirement for high school graduation was established in 1988 and includes: 4 credits of English, 3 credits of social studies, 2 credits of mathematics, 2 credits of science, and 1.5 credits of physical education. Wisconsin has a highly devolved system of school governance in which district boards are also encouraged, but not required, to supplement the minimum requirements with 8.5 credits in vocational education, foreign language, fine arts, and other electives (see Section PI 18.03 of the Wisconsin Administrative Code). These high school graduation requirements rank among the lowest in the nation, both in terms of the number of credits required in specific subject areas, and because the level of required courses is not specified. On average, states require 20 credits for a high school diploma, and 29 states require three or more years of math for that diploma (Achieve 2004).

The state's high school graduation requirements are not aligned with the course requirements for admission into the UW System which requires 17 courses, including 3 credits of math and 3 credits of science.[6] These higher requirements are consistent with those considered by the Washington D.C.-based organization Achieve to be indicators of a student's "college-readiness." States with high school requirements that are aligned with college-readiness requirements typically require four credits of math, usually with a minimum subject threshold of Algebra II. Indeed, students who are admitted to the most prestigious UW campus, UW-Madison, typically have taken at least 22 courses, including at least 4 years of math and science, as well as at least 4 years of social studies and foreign language. Thus, students who do not exceed the state requirements for high school graduation will not qualify for admission to college anywhere in the UW System.

While there is a national movement to reform high schools and increase graduation requirements, there is relatively little change taking place in Wisconsin. A 2006 survey conducted by Achieve found that Wisconsin had no policy in place nor plans to implement policies to align high school graduation requirements with either higher education or workplace expectations, to use existing high school assessments for college admissions, or to hold high schools accountable for college-entry rates.[7] This puts the state in sharp contrast to its neighbors, Michigan and Minnesota, both of whom have already completed or are in the process of completing many of these reforms.

The most common standardized test taken by Wisconsin high school students to qualify for college admission is the ACT. In 2006, 68 percent of high school graduates took the test, and averaged a composite score of 22.2, slightly above the national average of 21.1.[8] According to the organization administering the test, in order for a student to be college-ready the minimum ACT scores needed are a 22 in math and a 24 in science. In 2006, 52 percent of Wisconsin ACT test-takers met the math benchmark, and 35 percent met the science benchmark (compared to 42 and 27% nationally). ACT scores in Wisconsin have not changed over the last five years (ACT 2006).

Wisconsin students who take a more rigorous high school curriculum earn higher ACT scores. As noted earlier, the state minimum graduation requirement in math is two

[6] The minimum requirements are the same for all UW campuses, including the two-year Colleges. For more information, see: http://uwhelp.wisconsin.edu/admission/requirements/freshman/collegeprepreq.asp
[7] In his 2005 State of the State address, Democratic Governor James E. Doyle stated his intention to increase the high school graduation requirement in math; however since that time no action has been taken to legislate or implement that change.
[8] Wisconsin does not require all high school graduates to take the ACT, a policy recently implemented by its neighbor, Illinois.

credits, but 91 percent of ACT test-takers took at least three years of math. Students who took less than three years of math averaged an ACT math score of 18.9, compared to 19.0 for students who took Algebra I, II, and Geometry, and 25.0 for the six percent of students who went on to take Trigonometry and Calculus. Similarly, while the state requires only two years of science, 79.6 percent of ACT test-takers took at least three years of science. Those who completed a sequence of Biology, Chemistry, and Physics averaged a science ACT score of 24.2, compared to 20.4 for students completing only the state minimum (ACT 2006).

While Wisconsin's course requirements are relatively low, the state does offer a significant breadth of Advanced Placement (AP) coursework which can help to strength students' academic preparation for college and enhance their transcripts. These college-level courses are certified by the College Board, which also administers AP subject tests. Approximately one-fourth of Wisconsin districts do not offer any AP courses, but the state is working to change that via a partial reimbursement program meant to offset the costs incurred by districts offering the courses. Between 5 and 6 percent of secondary students take at least one AP exam each year, and 67 percent of test-takers pass their exams (scoring a 3 or above).

Thus, while high school graduation rates in Wisconsin are relatively high, the secondary school system does not operate to ensure that all students are prepared for and go on to college. Graduation requirements are kept to a minimum, college entrance examinations are optional, and AP courses are not consistently available to all students. It is therefore not surprising that less than two-thirds (58.5%) of Wisconsin public and private high school graduates enroll in college during the fall after high school graduation.[9] While this rate places Wisconsin above the national average, Wisconsin ranks 22nd nationally, behind its neighbors, Minnesota and Michigan. Furthermore, this rate has declined by 1.4 percent since 1994, consistent with national trends (Mortenson 2006).

[9] The college continuation rate does not distinguish between students attending a four-year rather than a two-year institution.

The Ecology of College Access

While a large body of research has documented the ways which demographic factors and high school preparation predict college attendance, very little attention has been paid to the way in which the provision of college-access policies and programs, and associated college-preparation behaviors, are organized in space in specific patterns. Yet all education data are inherently spatial, since students are educated in schools located at specific geographic locations, and research indicates that schools located in proximate areas, such as within a school district or even a state, are more likely to have similar outcomes than schools located farther apart (Epple 2003). Underlying spatial analysis is the notion that "if the locations change, the results change" and that "where you are makes a differences in social attitudes and behaviors" (Goodchild and Janelle 2004: 5; Weeks 2004: 383). To clarify, this approach differs from the proposition that distance to opportunity affects outcomes. Such an approach is the most common way in which higher education researchers have incorporated geography into college access studies. For example, several studies have shown that students tend to select colleges closer to their home, rather than ones located farther away (Rouse 1995; Turley 2006). In fact, the proximity of students to colleges is so closely associated with educational outcomes that it is often used as an instrument for level of education in studies examining the effects of education on wages (Card 1995). But social processes may be spatially structured in additional respects, most notably by operating in similar ways in clusters of neighboring areas with similar characteristics which are located apart from areas with different characteristics. This clustering may accentuate the college-going character and reputation of school districts by aggregating more college-going students in a delimited space. The reverse is also true--by concentrating non-college-going students in a delimited space, the clustering may enhance the 'non-college-going' character of a district. While scholars of urban processes have long considered neighborhood contiguity to be an important consideration, it is rarely studied with regard to college-going processes. Thus, the first question posed in this paper is:

(1) Are rates of college access across Wisconsin school districts organized in space in specific, non-random, patterns?

Wisconsin school districts vary significantly in terms of the demographic characteristics, student achievement levels, resources, and policies related to college access. For example, because the state sets such a low threshold for high school graduation requirements and leaves the allocation and distribution of 40 percent of possible credits required up to the districts, substantial variation is allowed to occur. One hypothesis is therefore that school boards in neighboring districts will reach similar decisions regarding requirements, and therefore hold their students to more similar standards. Similarly, the availability of AP courses in one district's high school may prompt nearby districts to also offer such courses. Furthermore, neighboring districts are apt to be more similar than dissimilar in terms of the pool of college-educated parents, household income, and racial composition--all factors which affect college continuation rates. These leads to our second exploratory question:

(2) Are observable predictors of college access including demographic composition, secondary student achievement, high school graduation requirements, and district resources organized across Wisconsin school districts in specific, non-random, patterns?

The clustering of students with more resources--both financial and social--into isolated pockets throughout the state is hypothesized to have driven down the college access rates in other parts of the state. In this way, via the intensification of college advantage and the diffusion of practices associated with access, place and space are thought to matter. Identifying whether such a process exists in Wisconsin requires us to address two additional questions. The first regards the existence of bivariate associations:

(3) Is the relationship between observable predictors of college access and rates of college access organized across Wisconsin school districts in specific, non-random, patterns?

The second question, to be addressed in future work, requires regression analysis:

(4) Does the spatial organization of predictors of college access contribute to the observed spatial distribution of rates of access across Wisconsin school districts?

Of course, the last question should only be raised if evidence of spatial processes is first identified via the exploratory analyses required to address the first three questions. If no evidence of spatial processes exist, no spatial modeling is required.

Data

We selected for our unit of analysis the Wisconsin school district. School districts are smaller and more refined units than the larger counties, or the Cooperative Education Service Areas (CESAs) across Wisconsin. Furthermore, district-level data is available from both the state's educational department and the U.S. Census Bureau. Finally, there is precedent in the college access literature for using districts as units of analysis, though it is more common to use high school-level data, when individual-level data is unavailable (CITES).

In order to compare rates of college access across Wisconsin school districts we obtained college enrollment data for every UW campus, disaggregated by Wisconsin public high school, for each of three years (2001-2003). These data were provided by the University of Wisconsin System and are not publicly available. We merged that data at the high school level with publicly available data on school district characteristics from the Wisconsin Department of Public Instruction and data on school districts published by the U.S. Census Bureau.[10] All but 19 Wisconsin school districts have only one high school and thus the college enrollment data for high schools very closely corresponds to that of districts in most cases.[11]

[10] We used the Census definition of school district. In Wisconsin there are a total of 434 school districts divided into three types: elementary, secondary, and unified. The ten unified districts have only secondary schools (grades 9-12), and the 53 elementary districts have only grades K-8 –thus those districts serve the same children, in order to provide education in all elementary and secondary grades. The remaining secondary school districts provide grades k-12. For our purposes we ignored data from the elementary districts because we were primarily interested in high school-level policies and outcomes. The students residing in those elementary districts are therefore represented in our data as being part of the unified or secondary district which serves them—in other words, since those students are claimed by two districts (either elementary and unified, or elementary and secondary), they are allocated to the non-elementary district for our purposes. Thus our sample consists of 381 school districts. Two of those districts (5599997 and 5599998) are undefined districts—one appears to be inhabited, while the other consists of mostly water. In neither case could we locate any actual schools. In order to allow for spatial analyses, we had to clearly identify the geographic boundaries for each school district, which we accomplished by merging Census boundary files for the secondary and unified districts, and then merging that file with a file identifying the centroids of each school district.

[11] We acknowledge that the existence of more than one high school in 19 districts is a cause for concern. If certain important aspects of college access operate at the high school rather than the district level, when multiple high schools are aggregated into districts we may miss meaningful heterogeneity. In future work, we will attempt to examine this concern by assessing variance instability.

The college access rate for each high school was calculated by dividing the total number of students from that high school who were enrolled in a UW two- or four-year campus in the fall, divided by the number of 12th graders attending that high school during the prior spring. In the 19 cases where a district has more than one high school, we took the mean college access rate, averaged across the high schools. In this paper we present analyses from 2003, meaning that the numerator is enrollment in fall 2003, divided by the size of the high school class in spring 2003. Students who attended college in the technical college system, the Wisconsin private colleges or tribal colleges, or who went out-of-state are therefore not included in the numerator of this college access rate. This is due to the difficulty in collecting enrollment data from the separate and diverse higher education institutions which are under different governance systems and keep their own data. However, only a minority of Wisconsin high school graduates attend college outside of the UW System: forty-six percent attend a public-college in-state, 6 percent attend a private college in-state, and 11 percent attend an out-of-state college.

We are primarily interested in examining those aspects of Wisconsin school districts which research suggests might affect levels of college access in a district. Through an exploration of the available data at the district level, we identified four sets of covariates related to demographic composition, secondary student achievement, high school graduation requirements, and district resources. We included seven measures of the demographics of school districts: total population; secondary school population; median household income; percent of households living below the poverty line; percent of households with a bachelor's degree; whether the district was urban or rural; and the percent of non-white students in the district. With the exception of secondary enrollment all of these measures came from Census data; the secondary enrollment is from the Wisconsin Department of Public Instruction. On average, Wisconsin school districts have 766 secondary students, and 68 percent of districts are in rural areas. The median family income is $43,710, just over seven percent of families are living in poverty, only 12 percent of households are headed by an adult with a bachelor's degree or higher, and 4.5 percent of students are non-white.

Because we expect districts with higher-achieving students to have higher college-going rates, we also examined several measures of secondary student achievement, focusing on ACT test-taking and scores, and Advanced Placement course-taking. In the average district, 57 percent of secondary students took the ACT in 2002--2003, and scored on average 21.80. Very small percentages (1.8-2.3%) of students were in AP courses in math or science. We contrast these indicators with the high school graduation requirements in districts, as measured by how district requirements compared to the state minimum requirements, and how they compared to the UW System minimum requirements for admission into any two or four-year campus. Only 27 percent of districts exceed the two credit State requirement in math, and as a result only 24 percent either meet or exceed the three credit UW requirement (a small number of districts require 2.5 credits in math; less than the UW requirement). One-fifth of Wisconsin districts exceed the two credit State requirement in science, and thus only 17 percent either meet or exceed the three credit UW requirement. On average, districts meet or exceed UW requirements in 60 percent of the core subjects, but this is largely due to the higher state minimum requirements in English and social science. Thus, we also calculated an alternative advanced course-taking measure which indicates the percent of core subjects in which a district meets or exceeds the UW requirements, after first requiring them to exceed the social science requirement. This measure has substantially more variation, with a mean of 42 percent and a standard deviation of 22.49.

Finally, we examined several school district resources thought to predict college-going rates: per pupil expenditure; teacher tenure (as measured by the percent of teachers with at least 5 years of in-district experience); teacher training (as measured by the percent with a master's degree or higher); and AP course offerings (total number of courses per 100 secondary students). In the average district, 67 percent of the teachers have at least 5 years experience and 35 percent hold a master's degree. Less than one AP course is offered per 100 secondary students, and the average per pupil spending is just over $9,000. Table 1 presents descriptive statistics on the sample of school districts.

<<<Table 1 here>>>

Methods

Despite concern about the uneven distribution of college-going rates throughout the state and the knowledge that the social background and academic preparation of high school students varies widely across Wisconsin, there is very little empirical evidence to indicate whether spatial processes actually affect the distribution of college access rates. Thus, it is difficult and indeed inappropriate to begin a systematic inquiry into those processes without first conducting an exploratory spatial data analysis (ESDA). Here we use techniques designed to describe and visualize spatial distributions and associations, which allow us to discover potentially explicable patterns (Anselin 1998, 1999; Messner et al. 1999; Messner and Anselin 2004; Oliveau 2005). This type of exploration is made possible by the availability of data in geographic information systems (GIS) format--we suspect the majority of states now have such data available.

As noted earlier, our units of analysis are Wisconsin school districts. Spatial analysis depends heavily on the spatial weight measurement, which defines the districts counted as "neighbors." We began by using two first-order lattice weights, Queen and Rook, and examined the data to see which weight was the best fit. The Queen is the higher level contiguous weight measure, which includes all common points around a district when determining neighbors and looks for 8-way connections. The Rook is the lower level weight measure, which includes common points in the diagonal (particularly each district corner; 4 points) when determining neighbors. Inspections revealed that (surprisingly) using the Rook weight generated the highest correlations in our data, and thus we proceeded to use it.[12]

We mapped each of the independent and dependent variables in our study across all Wisconsin school districts. We then assessed whether there was any evidence of spatial correlation, or 'clustering,' in our data.[13] This is a useful approach in that it allows us to formally test whether locational similarity is related to value similarity--or in other words, how contiguity between school districts is matched by specific attributes of those districts (Messner et al. 1999). Moran's I measure of spatial autocorrelation measures the strength and direction of spatial correlations (Anselin 1995). A spatial correlation denotes a non-zero covariance between the values on a random variable for neighboring locations. Specifically, for a given variable z at a location i:

[12] We recognize that the use of the rook weight is likely problematic, since it identifies districts adjacent at the edges only and thus ignores other potential neighbors. We intend to but as of yet have not yet examined second order contiguous weights, nor have we identified how many districts are counted as 'nearest districts' or how far any spatial effects might extend.

[13] We have not spent as much time thus far on assessing and exploring atypical observations. Understanding outliers in our data may prove illuminating, and thus it is a next step to take.

$$I = \frac{\sum_{i,j} W_{ij}(z_i - \overline{z}).(z_j - \overline{z})}{n} / \sigma^2(z)$$

Thus, the strength of the correlation is a function of the distance separating the observations. When data is distributed such that for any given measure high values are located nearer to high values, and low nearer to low, the data is said to exhibit positive spatial autocorrelation. When high values are found near low values, the data exhibit negative spatial autocorrelation. The Moran's I univariate statistic thus provides a global measure of spatial autocorrelation representing the average correlation across spatial units.

But global statistics assume homogeneity across the sample, and thus we used a second measure to examine local correlations, allowing for any possible heterogeneity in correlations across districts. Underlying the calculation of a local correlation is a theory that assigns to a cluster only those districts that depart significantly from a random distribution. Clusters are comprised of a single school district along with all the districts that surround it and share a border (or in this case the district corner, since we employed the Rook weight). In order to test the null hypothesis of no local spatial association, we used the LISA statistic (local indicator of spatial association; see Anselin 1995). The LISA is calculated for each point of observation in the data, and provides an indication of the extent of significant spatial clustering of similar values around that observation (significant in the sense that the patterns are unlikely to have occurred randomly). It is computed as:

$$I_i = \frac{\sum_j w_{ij}(z_i - \overline{z})(z_j - \overline{z})}{\sum_i (z_i - \overline{z})^2}$$

$$with \quad \sum_i I_i = \gamma . I$$

The sum of LISAs for all observations is proportional to Moran's I (global) measure of spatial association. We may observe high-high clusters, where the local correlation indicates a district with high college-going surrounded by other districts that on average have high college-going. We may also observe low-low clusters, where low college-going districts are surrounded by other low college-going districts. High-low outliers, where a district with a high rate of college-going is surrounded by districts with lower than average college-going rates, and low-high outliers, where a district with a low rate of college-going is surrounded by high rate districts, may also be identified. Finally, there may be localities with no significant autocorrelation.

Therefore, we explore the potential existence of spatial process affecting college access in Wisconsin using the set of indicators delineated earlier in the paper in order to identify spatial patterns in those indicators. The analysis is the same for each variable--beginning with descriptive statistics and a basic map, and then computing the global spatial correlation followed by the local spatial correlation. We display the global correlations in a table, and the local correlations in a map of LISA indices.

After identifying locations of clusters for each college access predictor, we then begin to relate those patterns to patterns in the college access variable. We do this by calculating bivariate Moran's I statistics. A bivariate correlation indicates whether districts with similar relationships between predictors and access are clustered together, whether there is heterogeneity in the data, and how strong the relationship is. Our analyses at this step are quite preliminary, and will be further examined following the conference.

Geographic Distribution of College Access

The percent of 2002-2003 12th grade students from a given district enrolled in a UW institution during the fall of 2003 ranged from 0 to 53.62 percent. As Figure 2 illustrates, districts with the lowest levels of access are located in three areas: the northwest corner of the state near Minnesota, the southwest region east and south of La Crosse, and the northeast portion of the state where the population is sparser and no UW four-year institution is located. Districts with the highest levels of access tend to be located in the urban southeast regions, such as those around Madison, Milwaukee, and Oshkosh. However, the map also clearly indicates that low and high access districts are scattered through the state outside of these primary regions. This makes it difficult to 'eyeball' any particular non-random patterns in the data. Thus, in the next step we used univariate correlations to identify any significant clustering.

<<<Figure 2 here>>>

Spatial Concentration of College Access

Are rates of college access across Wisconsin school districts organized in space in specific, non-random, patterns? The global Moran's I statistic is 0.29 and is significant, indicating that the distribution of access is non-random, but that access is not very tightly clustered (see Table 2). Further examination using LISA maps (see Figure 3) reveals that the three clusters of low access we observe in Figure 2 are significant, as is the high access cluster in the southeast. That is, in several areas of the state districts with higher rates of college attendance are spatially clustered near other such districts and districts with low rates of college access are located adjacent to other low districts. However, in the vast majority of the state, no such relationship exists--we see no evidence of clustering in the middle part of the state, and there is evidence of some statistically significant outliers (areas with levels of access very different from those in surrounding districts). Thus, while the Moran's I global statistic and the LISA lead us to reject the null hypothesis of spatial randomness, and we observe some local clustering, we do not find strong evidence that throughout the entire state of Wisconsin college access is organized spatially. Moreover, the interpretation of at least one of the significant clusters, that bordering Minnesota, is questionable--without data from Minnesota's institutions of higher education we do not know whether the low rates of access in our data indicate truly lower rates of college-going in those northwestern districts, or whether students in that border region are attending colleges out-of-state, rather in the UW System.[14]

<<<Table 2 here>>>

<<<Figure 3 here>>>

Spatial Clustering of Predictors of Access

Are observable predictors of college access related to demographic composition and educational policies organized across Wisconsin school districts in specific, non-random, patterns? In other words, do the factors contributing to college access have spatial properties? In the next part of our analysis, we looked closely at each of our covariates, to see if there were any 'hotspots' or 'coldspots' in the state where college-promoting behavior was common or uncommon.

[14] In X year, Minnesota and Wisconsin established a tuition reciprocity agreement, which has been fairly successful. Which way does the flow tend to go?

An examination of the descriptive maps for each of the covariates (not shown), serves to highlight those which appeared to be less evenly distributed throughout the state. Districts with higher levels of household income are concentrated in the southeast corner of the state, with lower income districts located in each of the three other corners. The southeast also appears to have a greater proportion of adults with a bachelor's degree, and a higher proportion of non-white residents. In the southeast, high school graduation requirements are not notably higher nor AP courses more commonly offered, however, ACT test-taking rates are higher, as is the percent of teachers with a master's degree.

These perceptions based on a visual inspection of maps were supplemented by the calculation of Moran's I statistics and LISA maps. Strong global relationships were observed for only five of the covariates we examined: median household income, percent of college-educated households, rates of ACT test-taking, per pupil expenditures, and teacher training. The relationship between neighboring districts was notably weak with regard to high school graduation requirements-- in contrast to the hypothesis that nearby districts would have similar requirements, we found little evidence of this (see Figure 4). This may be the byproduct of how we defined neighboring districts, and we will explore that possibility further, as well as examine course requirements in a school-level rather than district-level model.

<<<Figure 4 here>>>

But districts that are more financially advantaged do tend to be neighbors with other advantaged districts, and the LISA maps confirm this. There is a substantial cluster of low-income districts near other low-income districts in the north and west, while high-income districts neighbor high-income districts in the southeast (see Figure 5). The degree of clustering is much smaller for ACT test-taking, per pupil expenditures, and teacher training, and do not reveal the same dichotomy along the southwest/northeast diagonal (see Figures 6-8). Moreover, there is more evidence of outliers with regard to those covariates.

<<<Figures 5-8 here>>>

These results should therefore be interpreted with much caution. The global correlations for the majority of our covariates are weak, and only a small number of significant local correlations were identified. The maps may be revealing local deviations from the global pattern of spatial association, or they may indicate that the local correlations are an aberration, and therefore appropriately undetected by the global measure. In other words, the clusters observed in the LISA maps may be indicative of outliers, rather than a more general spatial patterning. The only factor associated with college access which is very clearly spatially structured in Wisconsin is household income.

Spatial Distribution of the Relationship between Predictors and Access

Lastly, we turn to the relationship between our covariates and rates of college access. Using the bivariate Moran's I statistic, we checked for evidence of any global associations which would indicate similar relationships in neighboring districts (see Table 3). We find some clusters of relationships in Wisconsin. Most notably, districts where there is a strong positive association between household income and college access are surrounded by districts with a similar association. We find comparable results with regard to urbanicity, ACT test-taking, and teacher training--in districts where those characteristics predict access, neighboring districts have similar relationships. The LISA maps (see Figures 9-12) for these indicators all show clustering along the southwest/ northeast diagonal, with low-low relationships more common in the northwest, and high-high relationships more common in the southeast. But the global statistics, even on these covariates, are weak, and there are numerous outliers evidenced in the LISA maps. We therefore do not have strong evidence that spatial dependencies in our predictors are related to the spatial dependencies in college access rates.

<<<Table 3 here>>>

<<<Figures 9-12 here>>>

To supplement the bivariate Moran's I statistics, in regression analyses not shown we used our covariates to predict the rate of college access at the high school-level, for the same sample of school districts used in the earlier analyses. Our results generally confirm that the strongest predictors of access in Wisconsin, among those we examined, are teacher training and ACT test-taking rates, which are positively associated with access and for which we found some evidence of spatial structuration. However, we also found that per pupil expenditures were negatively associated with access, and we found no evidence of spatial structuration for that indicator.

Conclusions and Future Directions

The exploration we undertook begins to provide new information on the extent to which demographic characteristics and high school preparation affect college access rates in school districts across Wisconsin in specific, non-random ways. While we have not yet identified strong evidence of spatial processes, our results are suggestive that they do exist. We found evidence that two of our demographic indicators (income and urbanicity), one indicator of student achievement (ACT test-taking rate), and one indicator of district resources (teacher training), are spatially distributed in Wisconsin in non-random ways which appear to have some relationship to the distribution of college access throughout the state. It is thus plausible that usual multivariate regression analyses which do not explicitly take into account the spatial nature of the data may provide a fairly accurate picture of college access processes statewide. However, our findings also point to the possibility of local processes, particularly in the northwest and southwest corners of the state. In the next stage of our inquiry, a more fine-grained geographically weighted regression (GWR) analysis, which will allow for the effects of predictors to vary across space, will allow us to further explore the specific processes at play within these regions, and will allow us to understand how they differ from Wisconsin as a whole. We do not yet have a strong theoretical framework to suggest how spatial processes affect access, and thus cannot specify a full spatial econometric model. Moreover, our analyses thus far suffer from numerous limitations, including the use of a less-than-optimal weight to define neighbors, and the absence of college enrollment data from neighboring states. It is clearly far too soon to draw policy implications from our analysis. However, that is the goal towards which we are working, beginning with this exploratory paper. Our most immediate next step is to determine whether the non-random spatial organization of predictors of access contribute to the observed spatial distribution of college access in Wisconsin.

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Table 1. Characteristics of the Sample: Wisconsin School Districts

Characteristic	Mean	SD
College Access Rate (2003)	30.00	8.90
Demographic Composition		
Total population	14115.00	35880.84
Secondary school population	766.11	1576.85
Household income (median)	43710.04	10243.08
In poverty	7.42	4.01
Households with a bachelor's degree	12.47	7.34
Rural	68.38	37.00
Minority	4.54	6.77
Achievement of Students in Secondary Schooling		
% taking ACT	57.00	10.76
ACT composite score	21.80	1.14
% in Advanced Placement math	2.34	2.89
% in Advanced Placement science	1.89	3.49
% in Advanced Placement foreign language	0.34	1.30
% in Advanced Placement: other	7.46	8.71
Total % in any Advanced Placement	12.04	11.81
High School Graduation Requirements		
Exceed State requirements in math (1=yes)	0.27	
Exceed State requirements in science (1=yes)	0.20	
Meet UW requirements in math (1=yes)	0.23	
Exceed UW requirements in math (1=yes)	0.01	
Meet UW requirements in science (1=yes)	0.16	
Exceed UW requirements in science (1=yes)	0.01	
Meet or exceed UW requirements in all core subjects (1=yes)	0.14	
% of core subjects in which district meets or exceeds UW reqs (A)	60.42	18.10
% of core subjects in which district meets or exceeds UW reqs (B)	41.98	22.49
Resources		
Per pupil expenditure ($)	9138.45	1001.68
% of teachers with at least 5 years in-district experience	67	12.44
% of teachers with at least a master's degree	34.89	17.31
Total number of AP courses per 100 secondary students	0.85	0.85

Notes:
1. Data is for 2002-2003 school year, to correspond to 2003 college access rate
2. Data is for 381 Wisconsin school districts
3. College Access Rate is percent of 2003 high school seniors attending any UW campus in fall 2003.
4. For UW requirement variables: The difference between A and B is that B's definition is more restrictive, requiring the district to exceed the requirement in social science, and then calculating the % of other subjects in which the districts meets or exceeds the UW requirement.

Table 2. Global Univariate Moran's I Statistics

Characteristic	*I* statistic
College Access Rate (2003)	0.2884
Demographic Composition	
Median household income (unstandardized)	0.5888
Median household income (standardized)	0.6497
Households with a bachelor's degree	0.5524
Minority	0.1669
Achievement of Students in Secondary Schooling	
% taking ACT	0.1721
ACT composite score	0.0616
High School Graduation Requirements	
% of core subjects in which district meets or exceeds UW reqs (B)	0.022
Resources	
Per pupil expenditure ($)	0.1601
% of teachers with at least 5 years in-district experience	0.0672
% of teachers with at least a master's degree	0.1991
Total number of AP courses per 100 secondary students	0.0997

Notes:
1. All correlations are significant at $p<.05$
2. Correlations are displayed only for non-dichotomous variables; spatial correlations cannot be calculated for dichotomous variables.

Table 3. Global Bivariate Moran's I Statistics

Characteristic	*I* statistic
College Access Rate (2003) with	
Demographic Composition	
Median household income (unstandardized)	0.3323
Median household income (standardized)	0.3376
Households with a bachelor's degree	-0.1372
Minority	-0.036
Rural	0.208
Achievement of Students in Secondary Schooling	
% taking ACT	0.1859
ACT composite score	0.1134
High School Graduation Requirements	
% of core subjects in which district meets or exceeds UW reqs (B)	-0.0932
Resources	
Per pupil expenditure ($)	-0.0828
% of teachers with at least 5 years in-district experience	0.0665
% of teachers with at least a master's degree	0.1239
Total number of AP courses per 100 secondary students	-0.012

Notes:

1. All correlations are significant at $p<.05$
2. Correlations are displayed only for non-dichotomous variables; spatial correlations cannot be calculated for dichotomous variables.

Figure 1. Distribution of Campuses in UW System

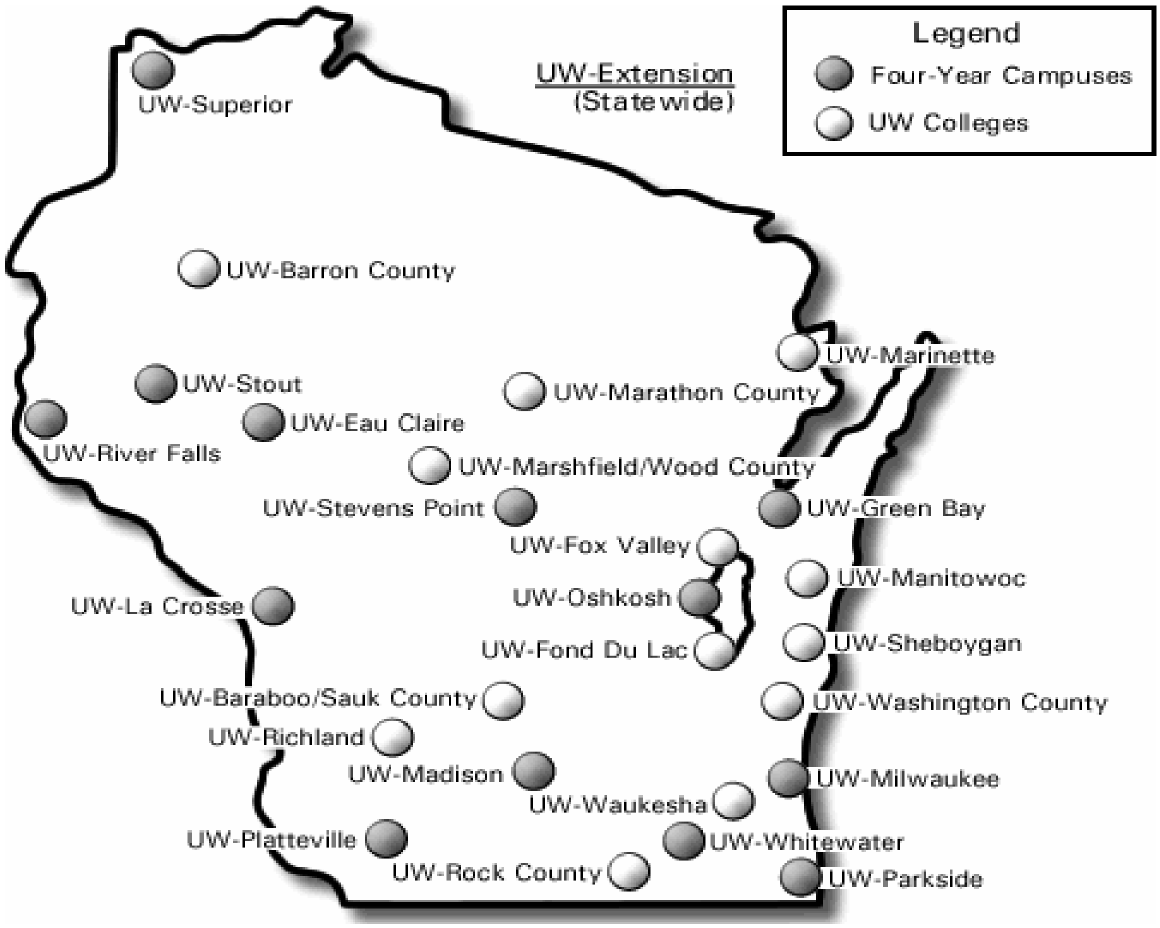


Figure 2. Distribution of College Access Rates: Wisconsin School Districts

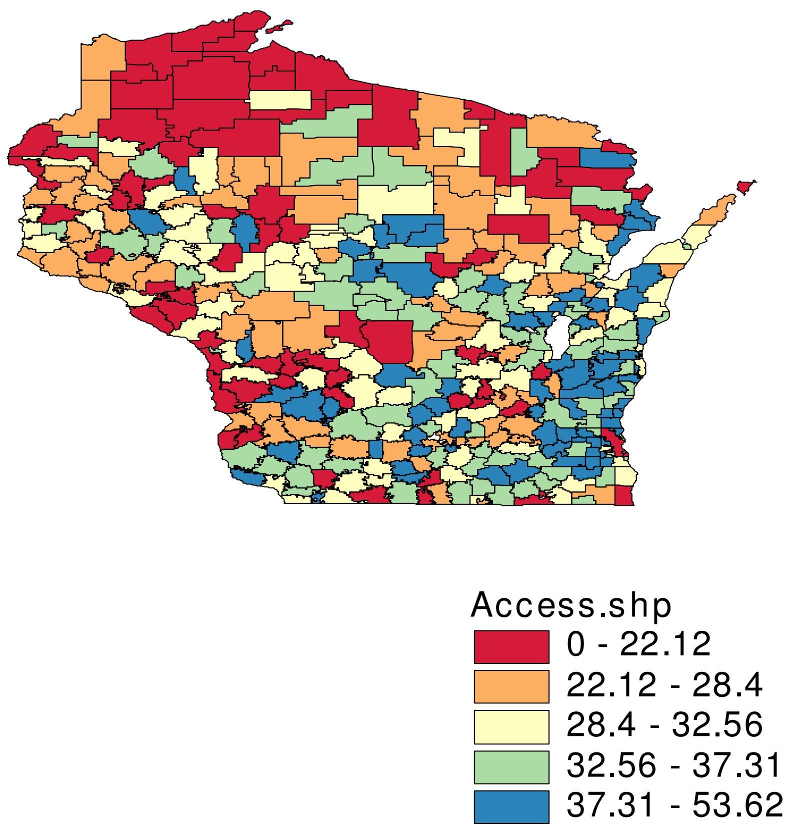


Figure 3. Univariate LISA Cluster Map: College Access

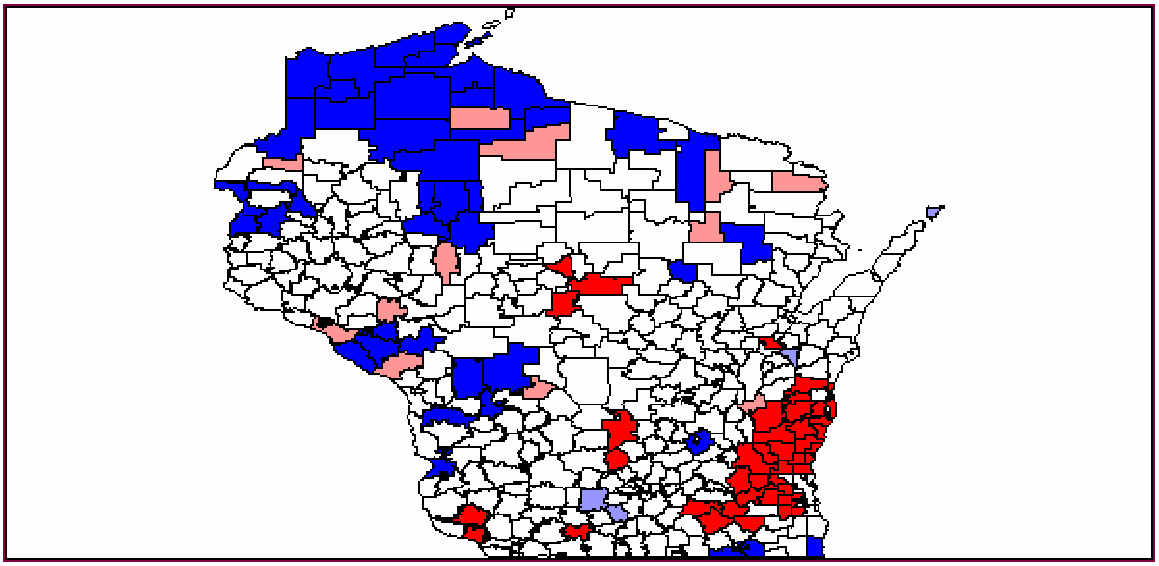
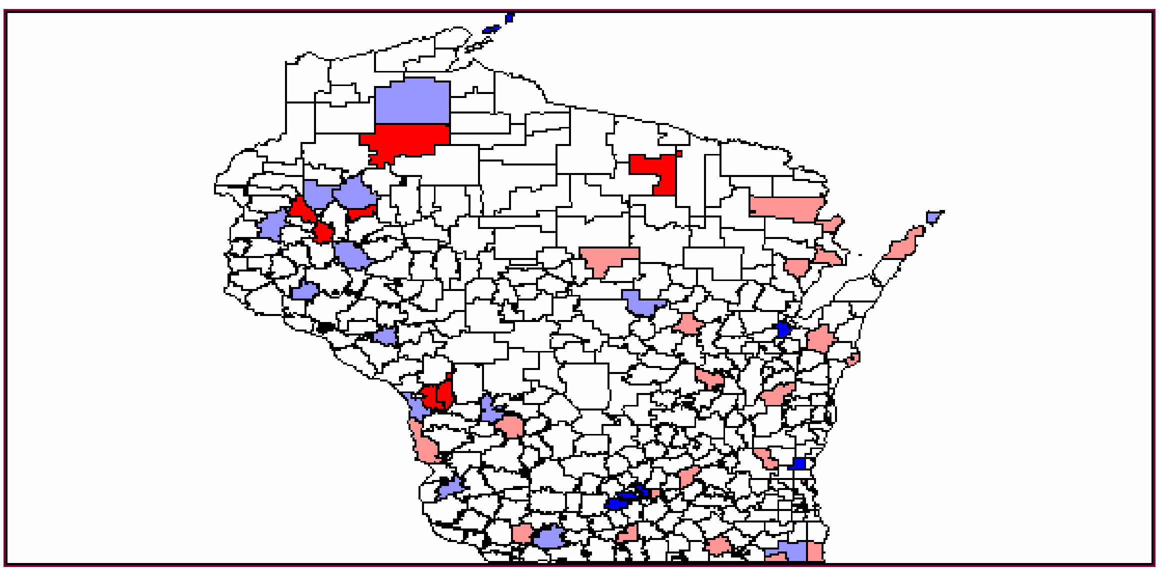


Figure 4. Univariate LISA Cluster Map: % of core subjects in which district meets or exceeds UW requirements (B)



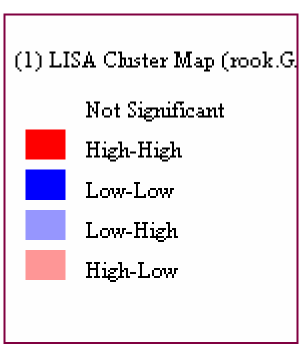


Figure 5. Univariate LISA Cluster Map: Median Household Income (unstand.)

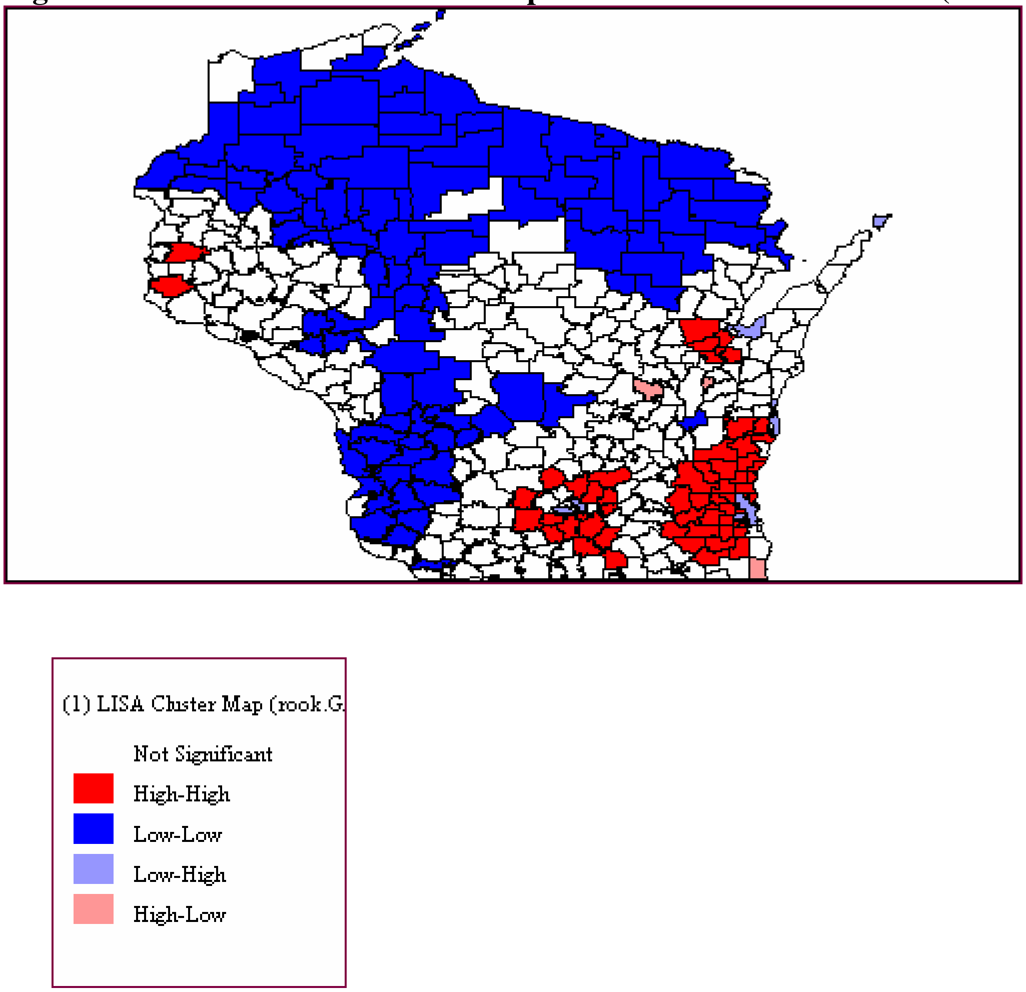


Figure 6. Univariate LISA Cluster Map: % taking ACT

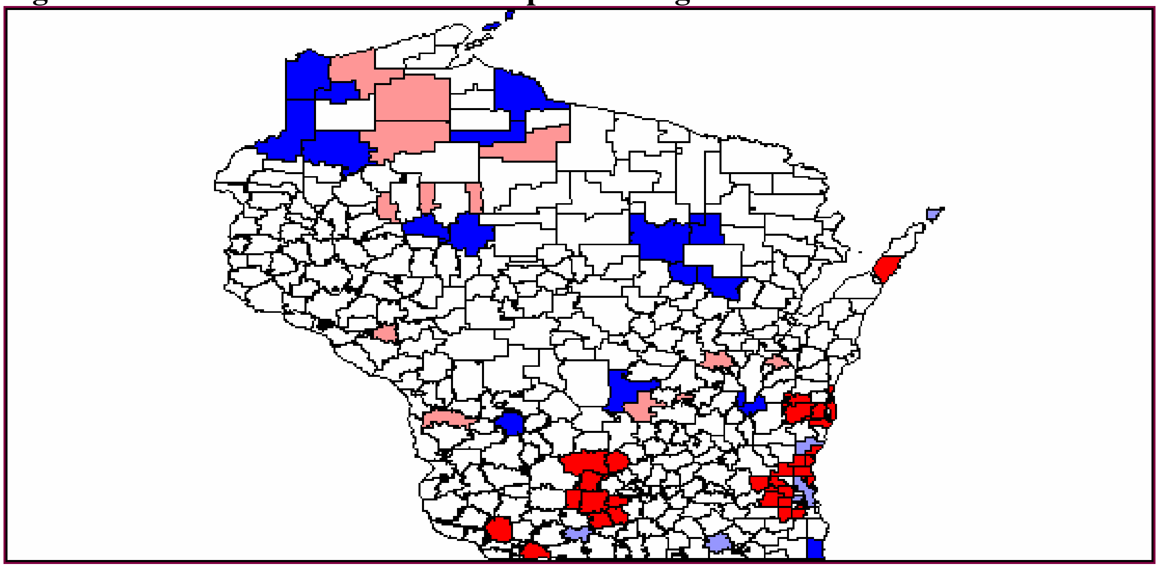
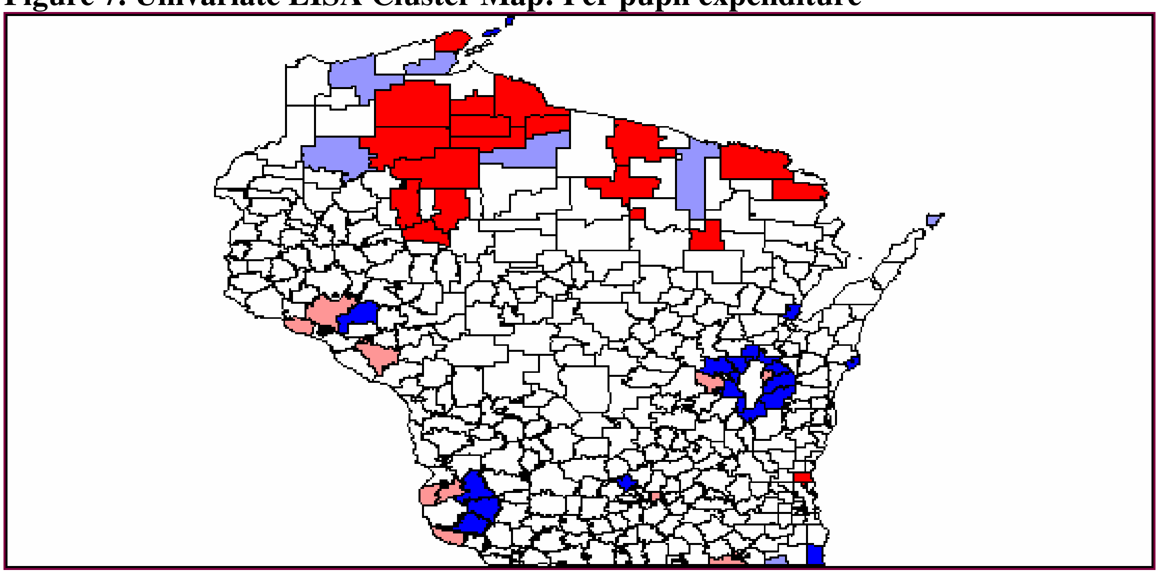


Figure 7. Univariate LISA Cluster Map: Per pupil expenditure



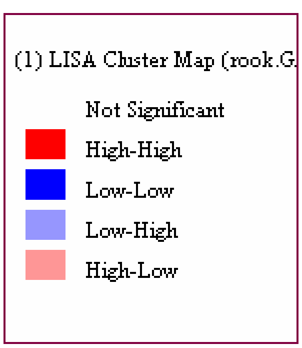


Figure 8. Univariate LISA Cluster Map: % of teachers with a master's degree

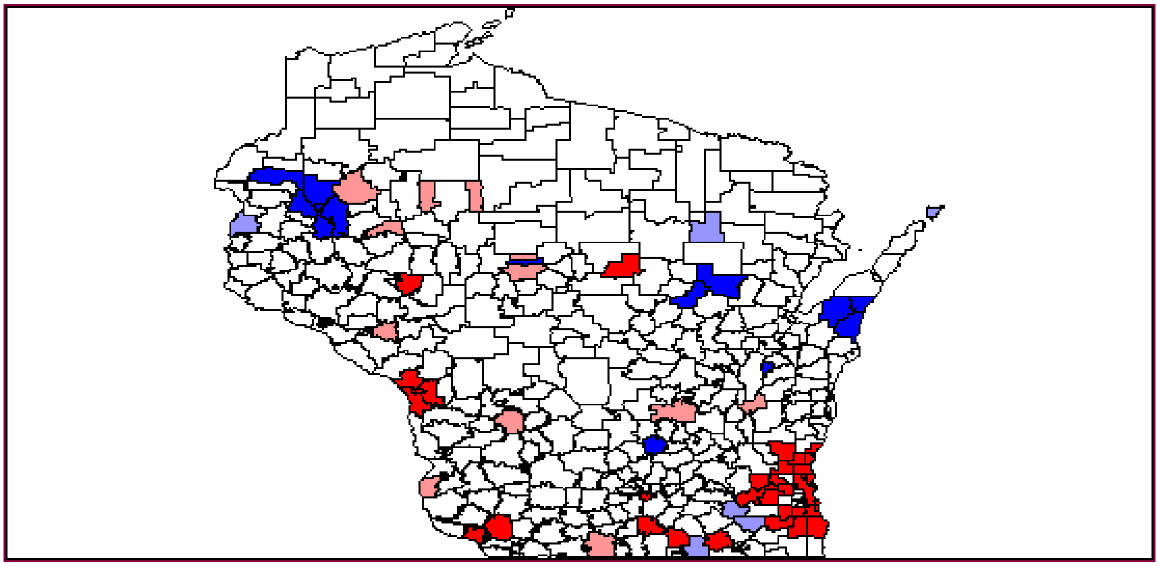
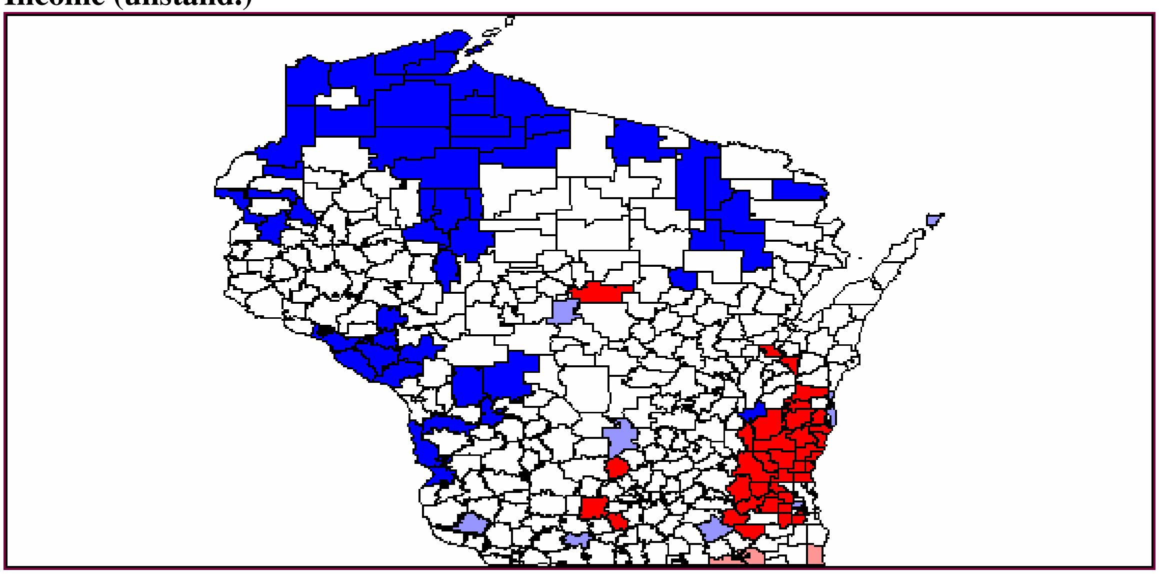


Figure 9. Bivariate LISA Cluster Map: College Access and Median Household Income (unstand.)



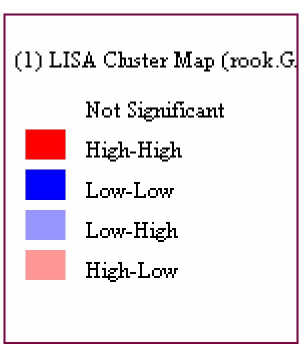


Figure 10. Bivariate LISA Cluster Map: College Access and Urbanicity

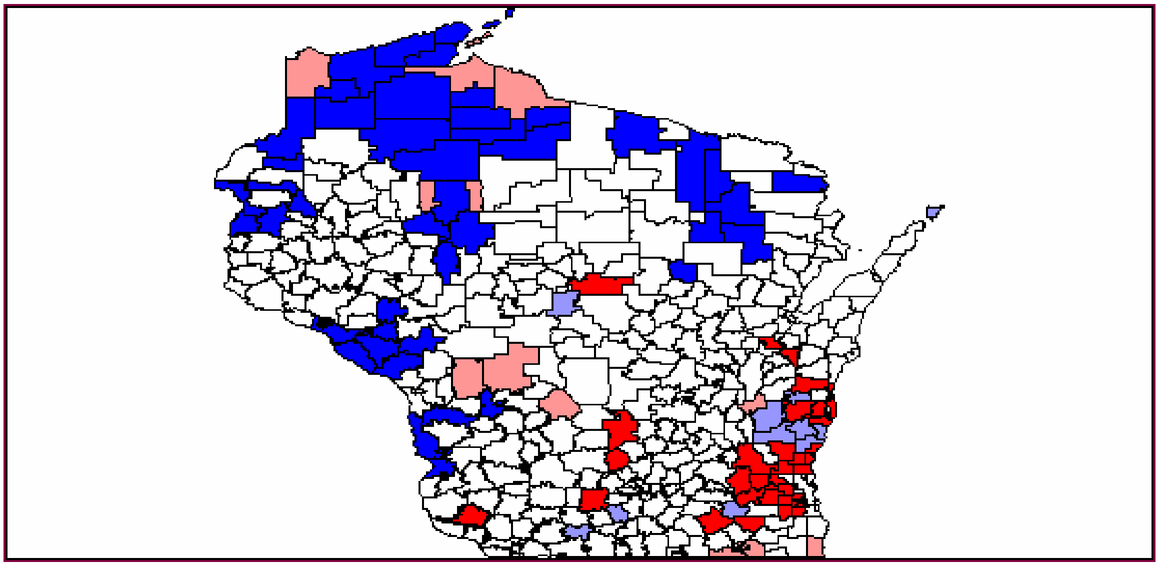
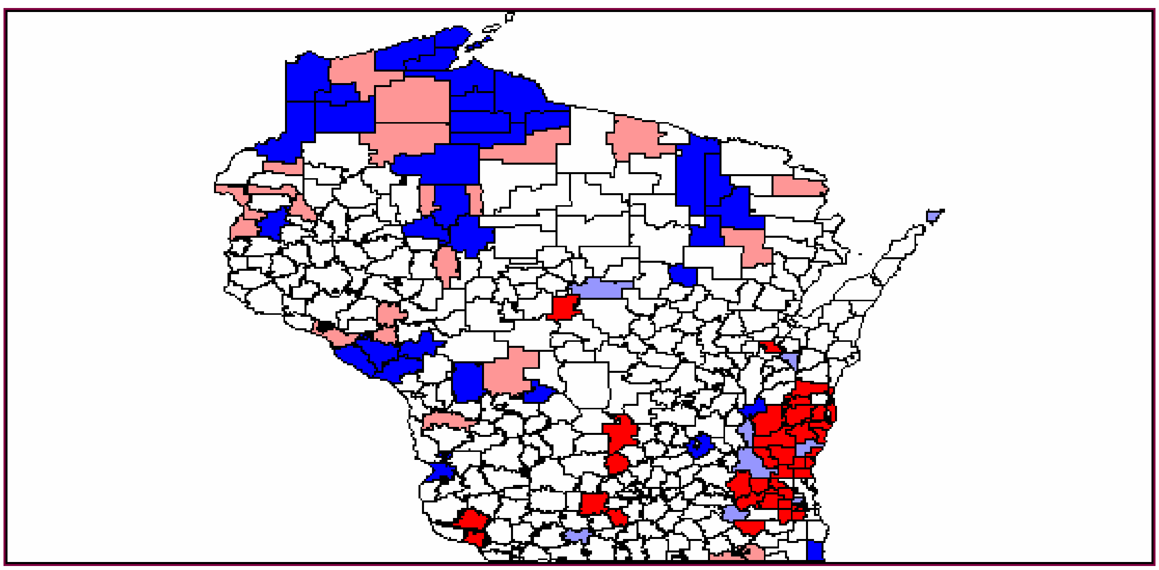


Figure 11. Bivariate LISA Cluster Map: College Access and % taking ACT



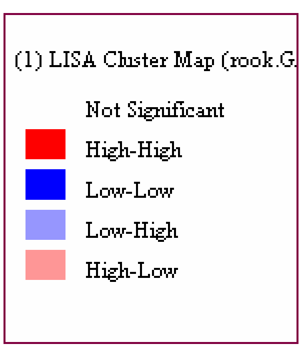


Figure 12. Bivariate LISA Cluster Map: College Access and % of teachers with a Master's Degree