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Spatial Analysis of Hartford Public School Student Characteristics across Census Block Groups, 2009-2012: A Preliminary Report

Diane Zannoni
Trinity College

Jack Dougherty
Trinity College

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By Diane Zannoni, Jack Dougherty,
with Sue Denning, David Tatem, Ned Hurwitch '13, and Jenna Wilborne '15
Cities, Suburbs and Schools Project at Trinity College
http://commons.trincoll.edu/cssp
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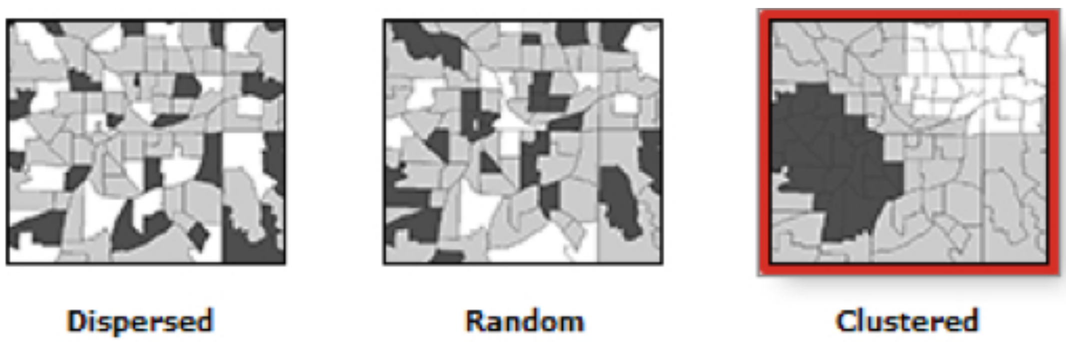
Introduction:
What is a "spatial analysis" and why do geographical patterns matter in research on student enrollment and school choice? In general, spatial analysis refers to the distribution of a variable across geography. If all things were equal, we would expect student characteristics to be randomly distributed over space, but other factors may cause them to be dispersed or clustered.



When spatial patterns emerge, it tells us that geography matters, for at least two possible types of reasons. First, geography may matter because people living near one another may behave similarly due to the sharing of information and decision-making that results from close proximity. Regarding school choice, parents who live in the same neighborhood may talk with one another and therefore decide to submit applications to the same schools. Second, another reason why geography matters is that it may serve as a proxy for another influential variable that we have not directly observed. For example, parents in the same vicinity may have similar economic characteristics (such as family income or home ownership) or they could have been influenced by an external factor (such as a community recruitment campaign or mailing), either of which may influence their school choice decisions. Since we want to know the reasons why people do (or do not) choose schools, we need to know more about spatial clusters because they may point to important geographical relationships or significant variables.

In our previous report, we examined whether high-achieving HPS students were randomly distributed across the district.[1] But in that study, our geographic analysis was limited because we only coded students based on four citywide transportation zones. This report goes a step further by offering a more granular analysis, based on coding student residence data to a smaller unit of analysis, their census block group, which allows us to search for deeper spatial patterns.

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[1] Diane Zannoni et al., *Student Continuity and Achievement Clustering in Hartford Public Schools, 2008-2012: A Preliminary Data Report*, Cities, Suburbs, and Schools Project (Hartford, CT: Trinity College, January 18, 2013), http://digitalrepository.trincoll.edu/cssp_papers/42/.

Data and methods:
We will be looking across census block groups in Hartford for spatial clustering in student demographic characteristics, student academic achievement, and student participation in school choice. With the cooperation of the Hartford Public School district, we obtained four years of student level achievement and demographic data, and masked these records to protect individual privacy, as described in our Trinity research ethics guidelines. We removed non-Hartford resident students from our analysis and geocoded all Hartford residents to identify their census block groups for neighborhood-level analysis. Our study examines only students in grades 3 through 8 due to the continuity of the fourth generation Connecticut Mastery Test (CMT) scores for these grade levels during our period of study from 2008-09 to 2011-12.

All variables in this study were derived from the HPS dataset unless noted otherwise. For CMT Goal and the racial composition of each school, we referred to data that we had previously obtained from the Connecticut State Department of Education (CSDE), as well as definitions and calculations we previously used when presenting school-level data in the SmartChoices website (see details on the "About" page of http://SmartChoices.trincoll.edu).

This study includes only Hartford-resident students enrolled in Hartford Public Schools (both HPS-run interdistrict magnets and district schools) in grades 3 to 8. We defined this population based on the HPS student-level enrollment and achievement datasets that the district provided to us, and therefore our analysis does NOT include Hartford-resident students enrolled in other public schools, such as:

- CREC-run interdistrict magnet schools, and other non-HPS managers
- Open Choice suburban districts
- other non-HPS public schools (such as Achievement First and Jumoke charter schools)
- non-regular HPS programs (Hartford Transitional Academy, outplacement, etc.)

We have requested that CSDE provide data on all RSCO-sponsored schools and these data are forthcoming for future reports.

Important definitions that we use in this study are:

- Hartford Public Schools - any district school or inter-district magnet operated by HPS
- HPS students - Hartford-resident students enrolled in HPS-run schools (usually G3-8)
- HPS district choice - NOT to be confused with RSCO interdistrict choice programs
- Composite Level CMT score - the composite average of three major level student test scores (reading, writing, math)
- High-achieving students* - those scoring at 4 or higher on composite CMT. On the five-point CMT scale, 1 is "below basic," 2 is "basic," and 3 is "proficient," which we distinguished from the high-achieving scores: 4 is "goal" and 5 is "advanced."

*For both Composite level CMT score and High-achieving students, this study includes only HPS students who received CMT scores in ALL three major subject areas (reading, writing, and math). Students who were exempted from one or more CMT subject tests (for example, due to special education or English language learner status), or did not receive one of these major CMT scores for any reason, do not appear in this study.

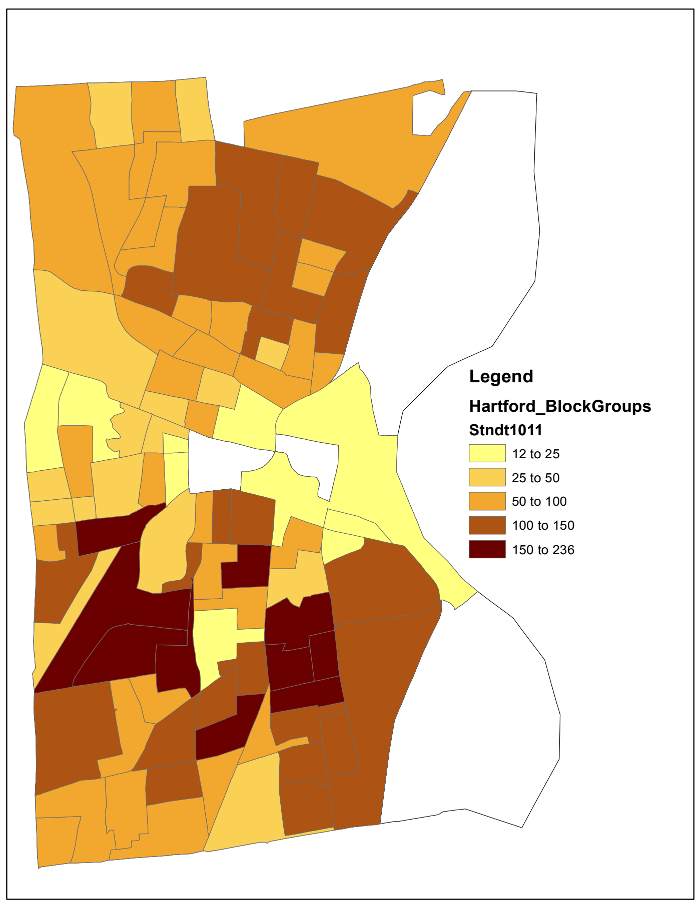
For the HPS district choice program, we analyzed "voluntary choosers" (who applied to transfer between non-magnet HPS schools) between grades 3-7, as opposed to transitional choosers (who are required to apply to enter a new school at Kindergarten or grade 9 in most cases). Our prior presentation examined spring 2010 HPS district voluntary choice applicants and non-applicants to determine how the two groups differed.[2] Since that time, we obtained two additional years of HPS district choice application data for spring 2011 and 2012.

HPS district choice	Voluntary choosers, grades 3-7	Percent of potential voluntary choosers, grades 3-7
spring 2010	227	3.4%
spring 2011	394	6.6%
spring 2012	208	3.3%

Due to changes in HPS district choice application procedures and data collection over time, we are not confident in the quality of the data we received for spring 2011.

For the spatial analysis, we matched HPS student residence data (typically updated to the end of the school year, or June) to the 2010 census block group. In a typical year, such as 2010-11, we geocoded 8,165 HPS grade 3-8 students residing in 96 census block groups in Hartford, as shown in map 1. To reduce the influence of low-population areas in this study, we excluded from the spatial analysis any census block group with fewer than 10 students, and these appear as hollow areas in the maps that follow.

Map 1: Distribution of HPS G3-8 Students, 2010-11



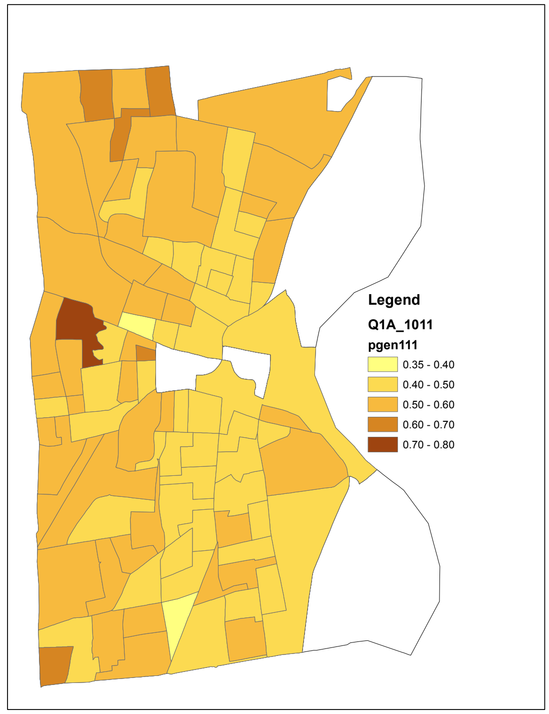
[2] Matthew DelConte et al., *Who Chooses? A Preliminary Analysis of Hartford Public Schools* (Hartford, CT: Cities Suburbs Schools Project at Trinity College, January 2012), http://digitalrepository.trincoll.edu/cssp_papers/37.

Organization of results:
How will we be presenting and analyzing patterns? We will show you: (1) maps of the geographical distribution of student characteristics, (2) tests for the statistical significance of spatial clustering, and (3) maps of geographical hot-spots, i.e, where the highs and lows of clustering take place.

1) Distribution maps: First, we can look at a map of a particular characteristic of the students residing in each census block group. Then we can try to visually discern from the map if there any evident patterns across census block groups. Rather than mapping raw numbers of students, we display the proportion of students with certain characteristics to correct for differences in census block group populations.

In map 2, one would expect that the proportion of male students in each census block group would show no pattern. In fact, we would expect that proportion to be more or less uniformly distributed across census block groups.

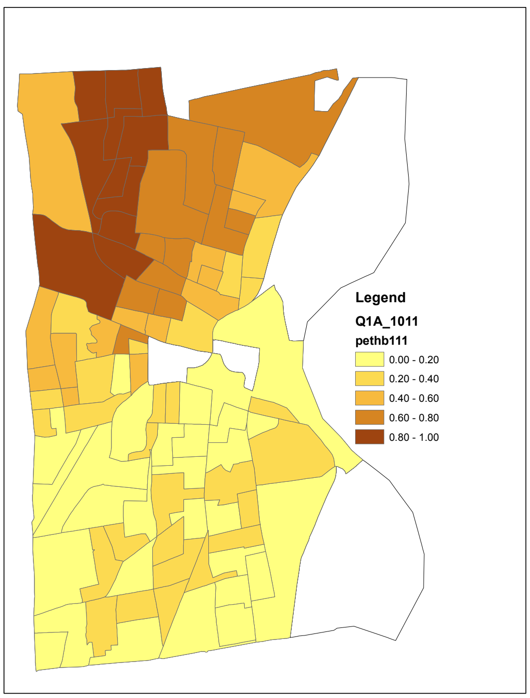
Map 2: Proportion of Male Students, 10-11



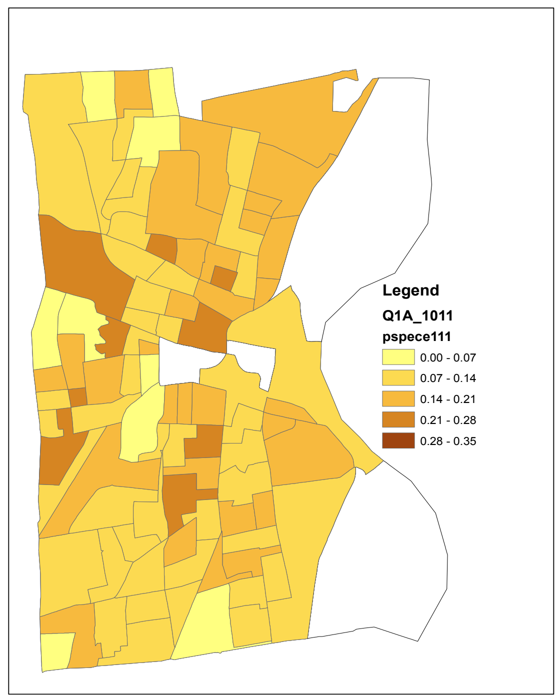
But we would expect a pattern to be visible on a map of the proportion of black students across census block groups in Hartford, as shown in distribution map 3. Due to Hartford's racial history, we would expect the north end to have many census block groups with a high proportion of black students and the south end to have many census block groups with a low proportion.

By contrast, we may have no prior hypothesis about the distribution of the proportion of special education students, as shown in distribution map 4.

Map 3: Proportion of Black Students, 10-11



Map 4: Proportion of Special Ed Students, 10-11



2) Tests of statistical significance of spatial clustering: There are times when we want to be more precise about concluding whether there is a pattern based on what we believe we see on a map. There is a possibility that the pattern we see is not a pattern (we just think we see a pattern) or that the pattern is due to random chance. Luckily, we can statistically test to see if there is a statistically significant spatial clustering or dispersion. Essentially, the test is to see if the characteristic is randomly distributed across the census block groups. If not, then the characteristic is either more clustered or more dispersed that it would be, if it were randomly distributed across census block groups. For this we calculate a statistic called the Moran's I and from that a z score can be calculated.

For example, we can conclude that the proportion of black students is spatially clustered, as shown in figure 1. This was apparent visually when we examined the distribution map, but now we can confirm it for 2010-11. At the 5% level of significance (the orange cut-off in the z-distribution below), we can conclude that there is clustering of the proportion of black students in Hartford, i.e., the z score at 14.06 is greater than 1.96.

If we test to see if there is significant concentration of special education students, we see that at the 5% level of significance, we would conclude that special needs students in 2010-11 are randomly distributed in Hartford, i.e., the z score at 1.73 is less than 1.96, as shown in figure 2.

Figure 1: Statistical test, Proportion of Black Students, 10-11

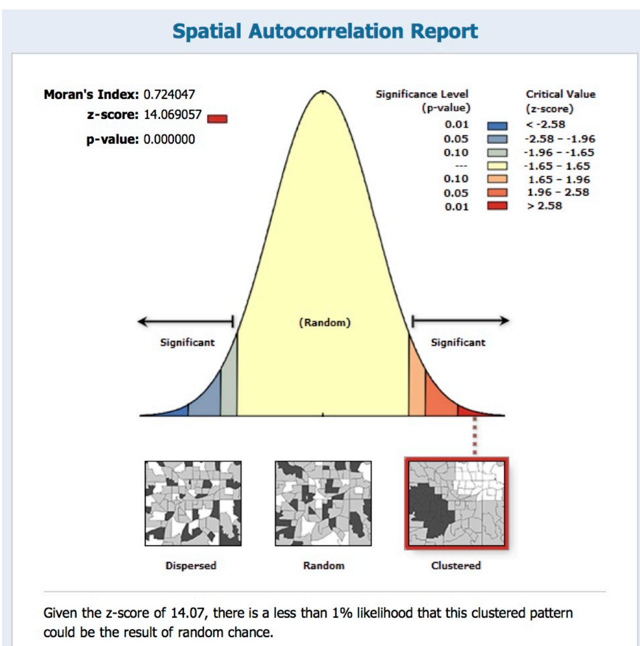
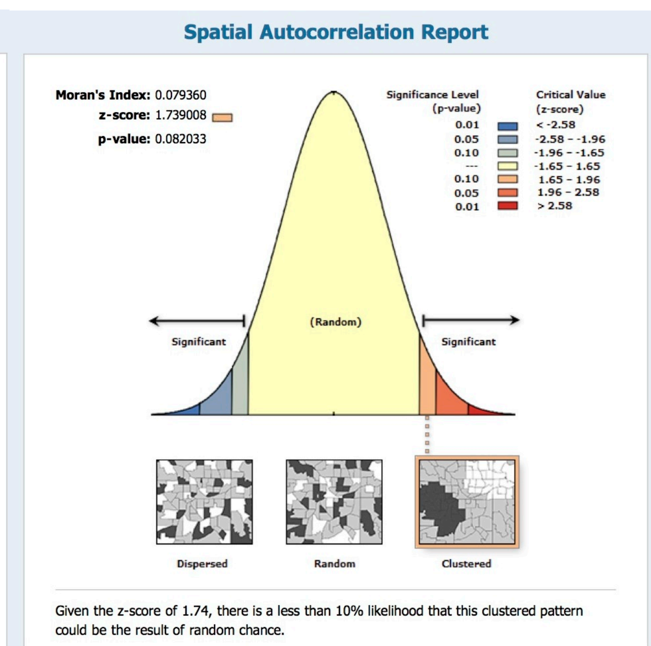


Figure 2: Statistical test, Proportion of Special Ed Students, 10-11



If we determine that there is spatial clustering, we also can see if block groups with census students with that characteristic are becoming more clustered over time. For 2011-12 the z score for the proportion of black students rose from 14.06 to 17.85, as shown in figure 3. This suggests that black students became more clustered from 2010-11 to 2011-12.

Let's turn back to the special education students. In 2011-12, there is now evidence of significant clustering of special education students at the 5% level of significance, as shown in figure 4. The z score rose from 1.74 to 2.37.

Figure 2: Statistical test, Proportion of Black Students, 11-12

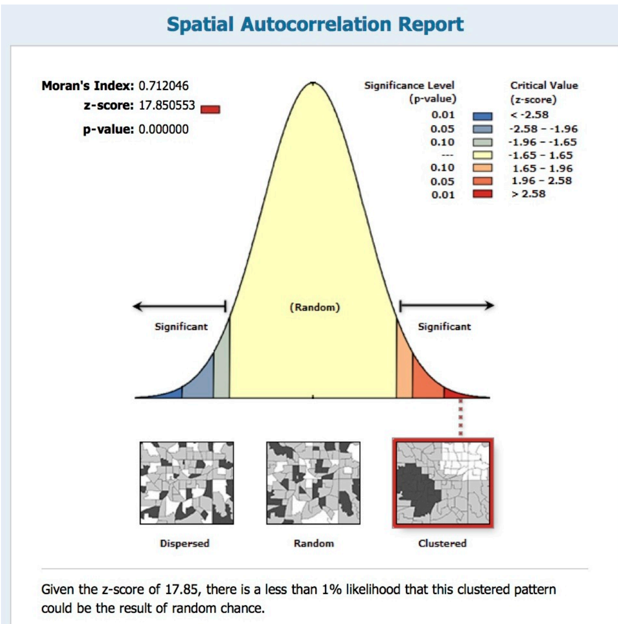
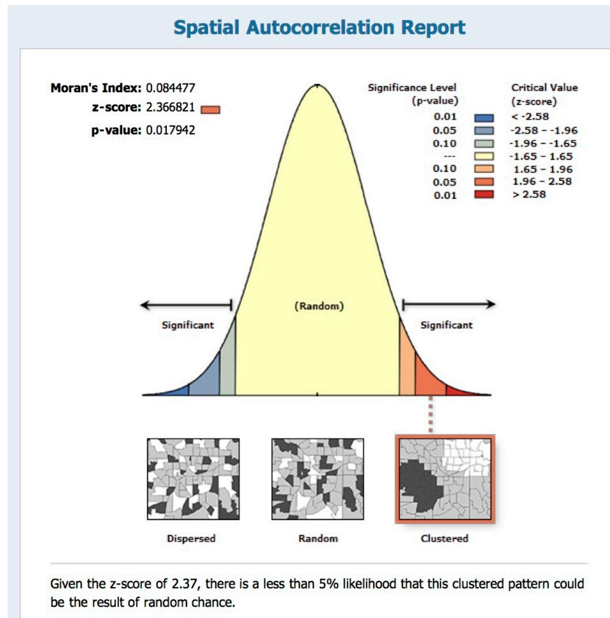
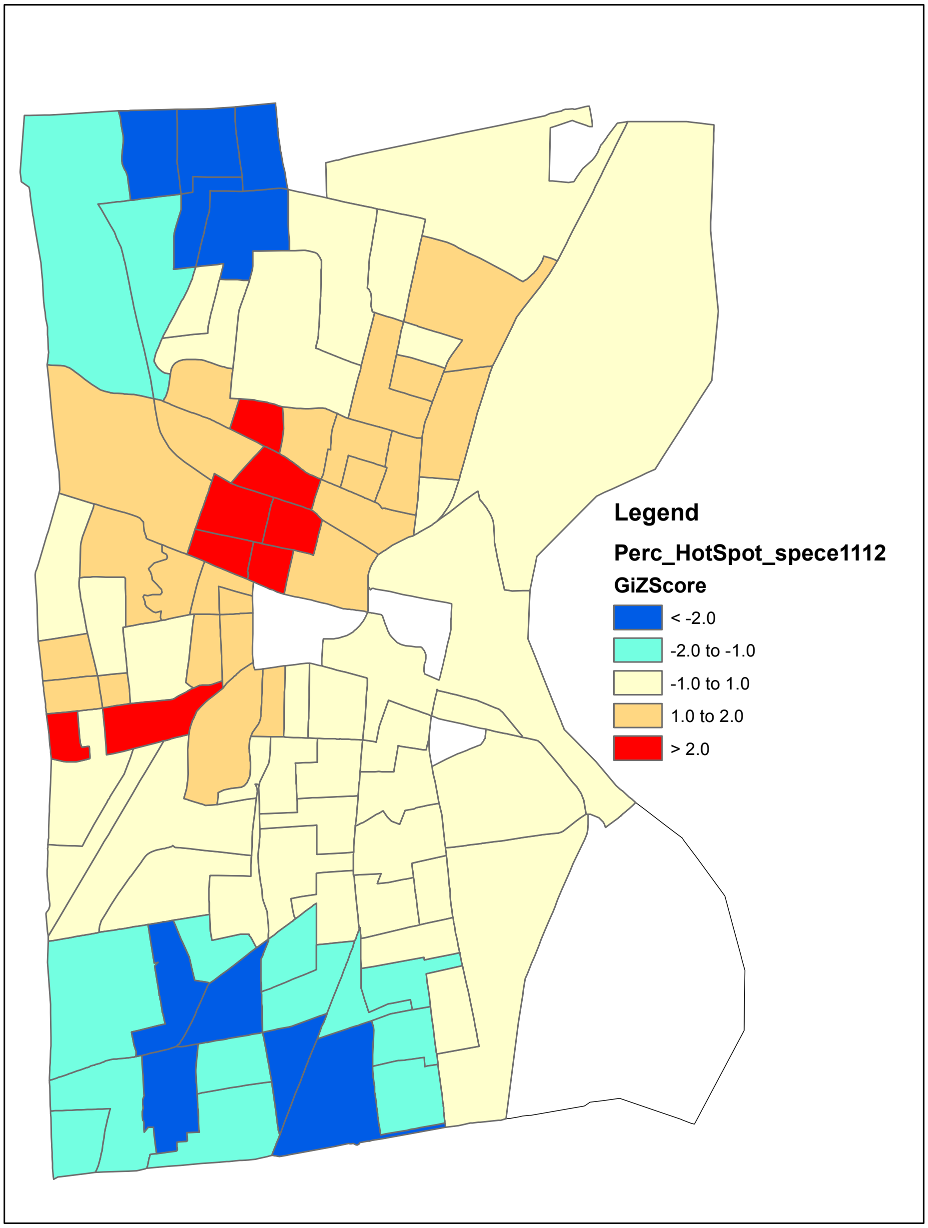


Figure 1: Statistical test, Proportion of Special Education Students, 11-12



3) Maps of geographical "hot spots": Finally, if we do find statistical evidence of spatial clustering, we want to know where there is especially high and low clustering of students with a particular characteristic. Using special education students in 2011-12 as an example, map 5 shows the areas of high concentration, where the proportion of special education students is more than 2 standard deviation above the mean (shown in red), and of low concentration, where the proportion is more than 2 standard deviations below the mean (shown in blue).

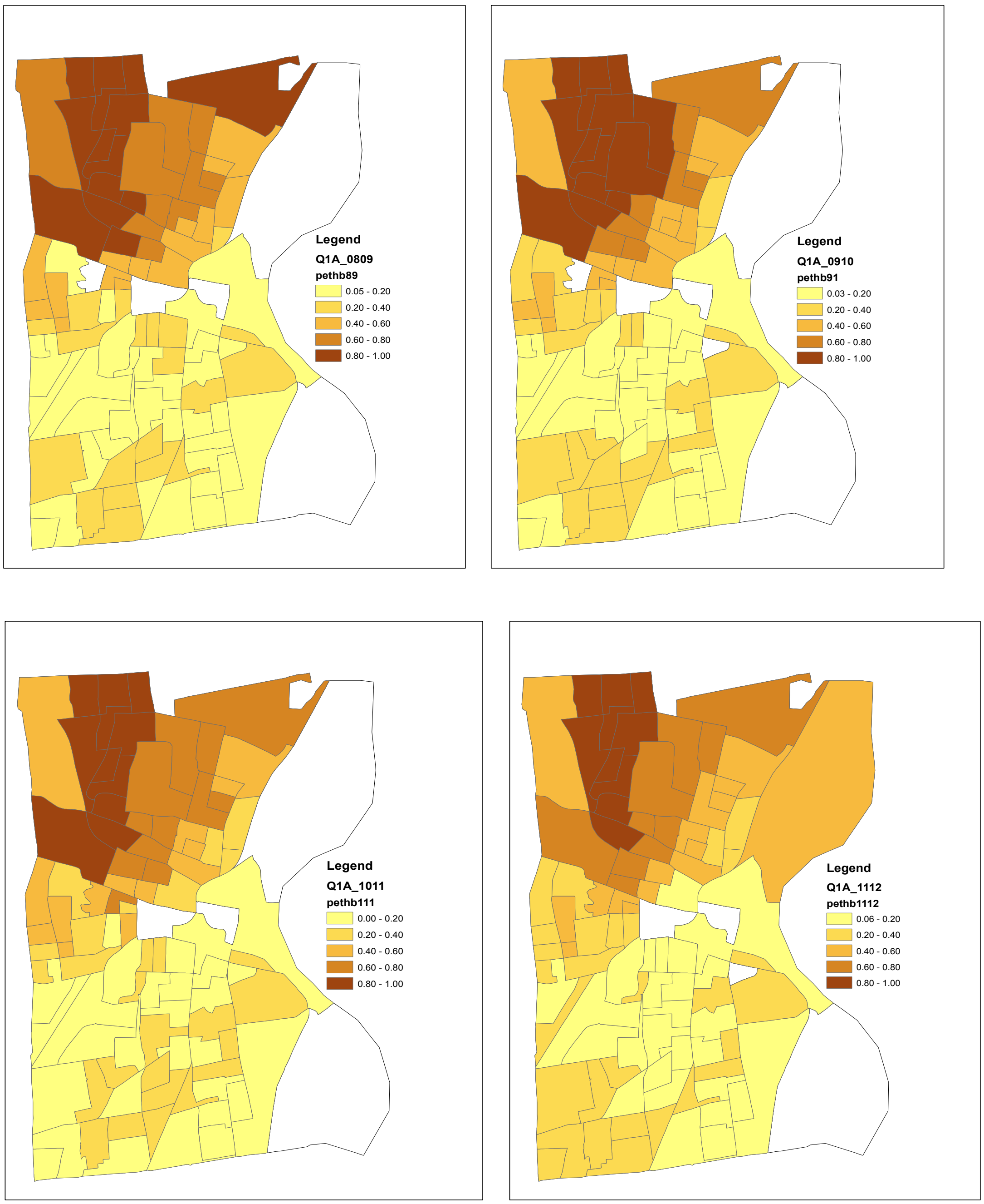
Map 3: Geographical hot spots, Proportion of Special Ed Students, 11-12



Results Part 1: Distribution maps of selected variables over time We turn now to look more closely at the distribution of students with four different characteristics over the four years.

From 2008-09 to 2011-12, the number of census block groups with a high proportion of black students appears to have remained high and stable in the North End of Hartford.

Maps 6: Proportion of Black Students, 09-12

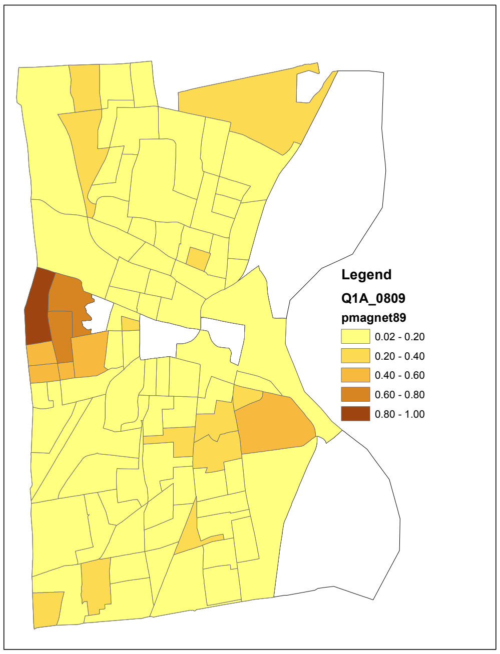


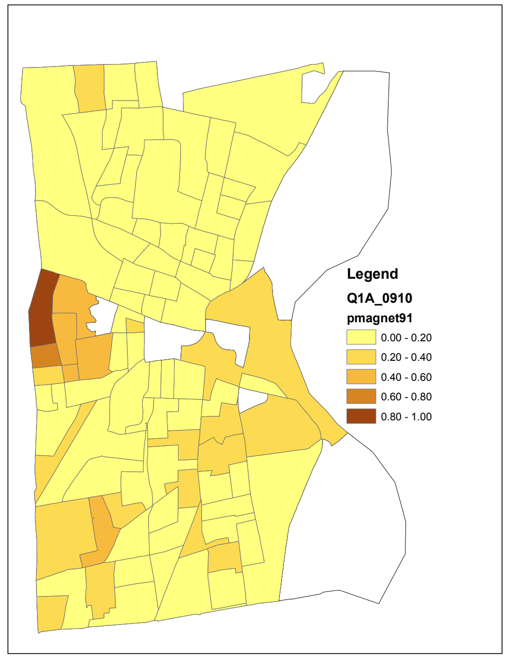
Over the four years, the proportion of Special Education students appears to be randomly distributed until the final year, 2011-12, when more census block groups have proportions in the .14-.21 range and those census block groups appear clustered.

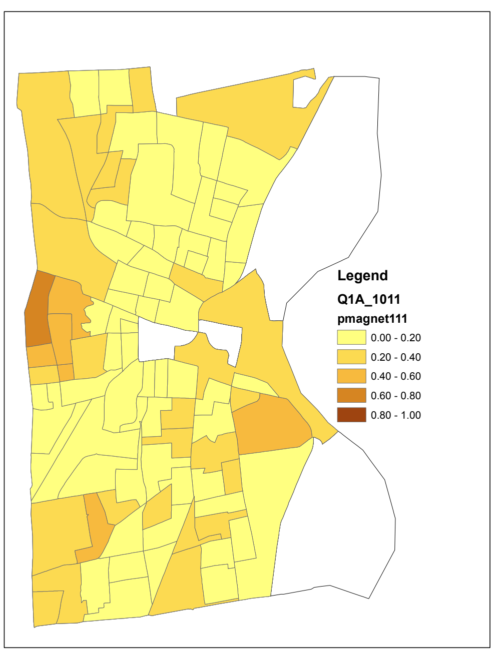
Maps 7: Proportion of Special Education Students, 09-12

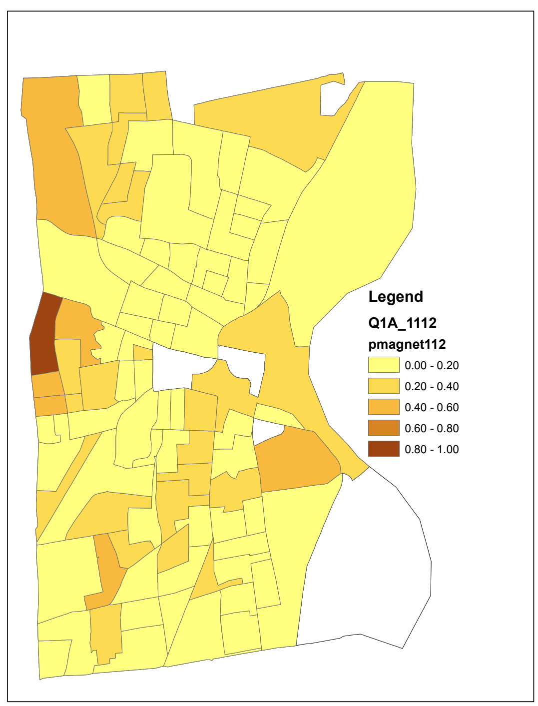
When we look at the distribution map of the proportion of students who attend HPS magnet schools, there appears to be higher proportions in census block groups on the western side of the city for all four years.

Maps 8: Proportion of HPS Magnet School Students, 09-12









Maps 9 illustrate the distribution of the average school CMT score of all students residing in each census block group. Students residing in the western, and central, regions of the city (excluding the hollow low-population zones) attend schools with higher average CMT scores.

Maps 9: Average CMT Scores of Student's School, 09-12

Results Part 2: Statistical Test of Spatial Clustering of selected variables, 2008-09 to 11-12

The results presented in Table 1 allow us to answer two questions: whether there is statistically significant clustering of students with specific characteristics, and if the clustering has increased or decreased over the four years.

Gender is randomly distributed, as expected. There is clustering of where student reside by race, which increased. In addition, the proportion of students who are in a minority in their school is becoming less clustered. Clustering of ELL students has risen. While there was no evidence of the clustering of special education students before 2011-12, there is clustering in 2011-12. There has been a slight decline in the clustering of students attending Hartford magnets.

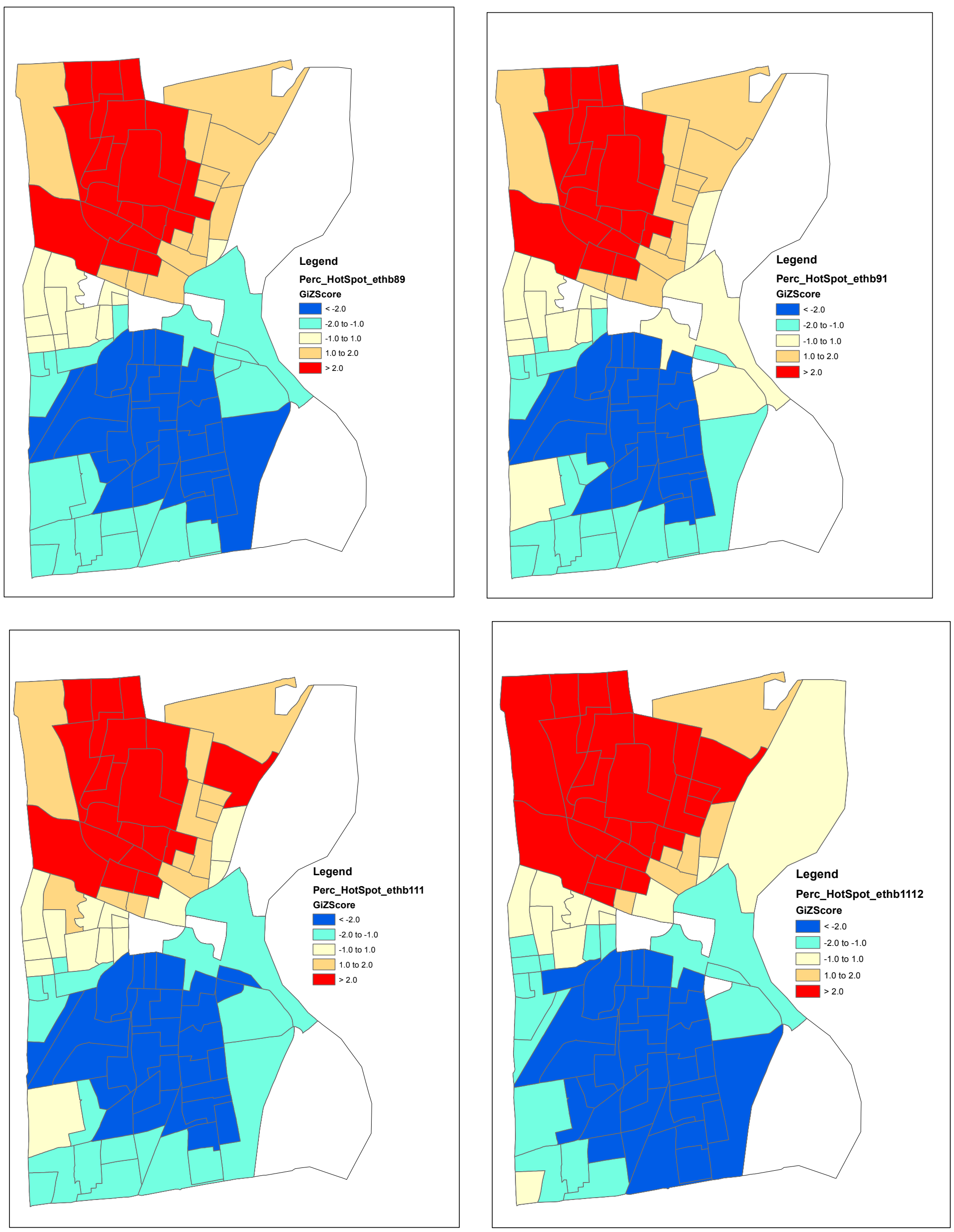
The clustering of student school CMT scores has risen.

Table 1: Statistical tests of spatial clustering, HPS G3-8 students				
Moran's I z-scores	**2008-09**	**2009-10**	**2010-11**	**2011-12**
Demographics: Proportion of students residing in census block group				
Male	*0.44*	*1.36*	*1.13*	*0.896*
Black	**14.3**	**14.87**	**14.06**	**17.85**
Hispanic	**13.87**	**14.44**	**13.37**	**17.06**
White	**6.29**	**7.16**	**5.12**	**6.06**
Minority in current school	**7.88**	**9.91**	**9.52**	**6.68**
English language learners	**11.14**	**12.82**	**10.7**	**13.72**
Special education	0.73	*0.15*	*1.74*	**2.37**
Attend HPS magnet	**8.03**	**7.67**	**7.2**	**6.68**
Achievement				
average school CMT score of students residing in census block group	**11.39**	**10.8**	**5.56**	**8.37**
DEFINITIONS: **bold =** clustered at 5% level of significance *italic* = not significant at 5%				

Results Part 3: Hot Spot Map Analysis of selected variables, 2008-2012

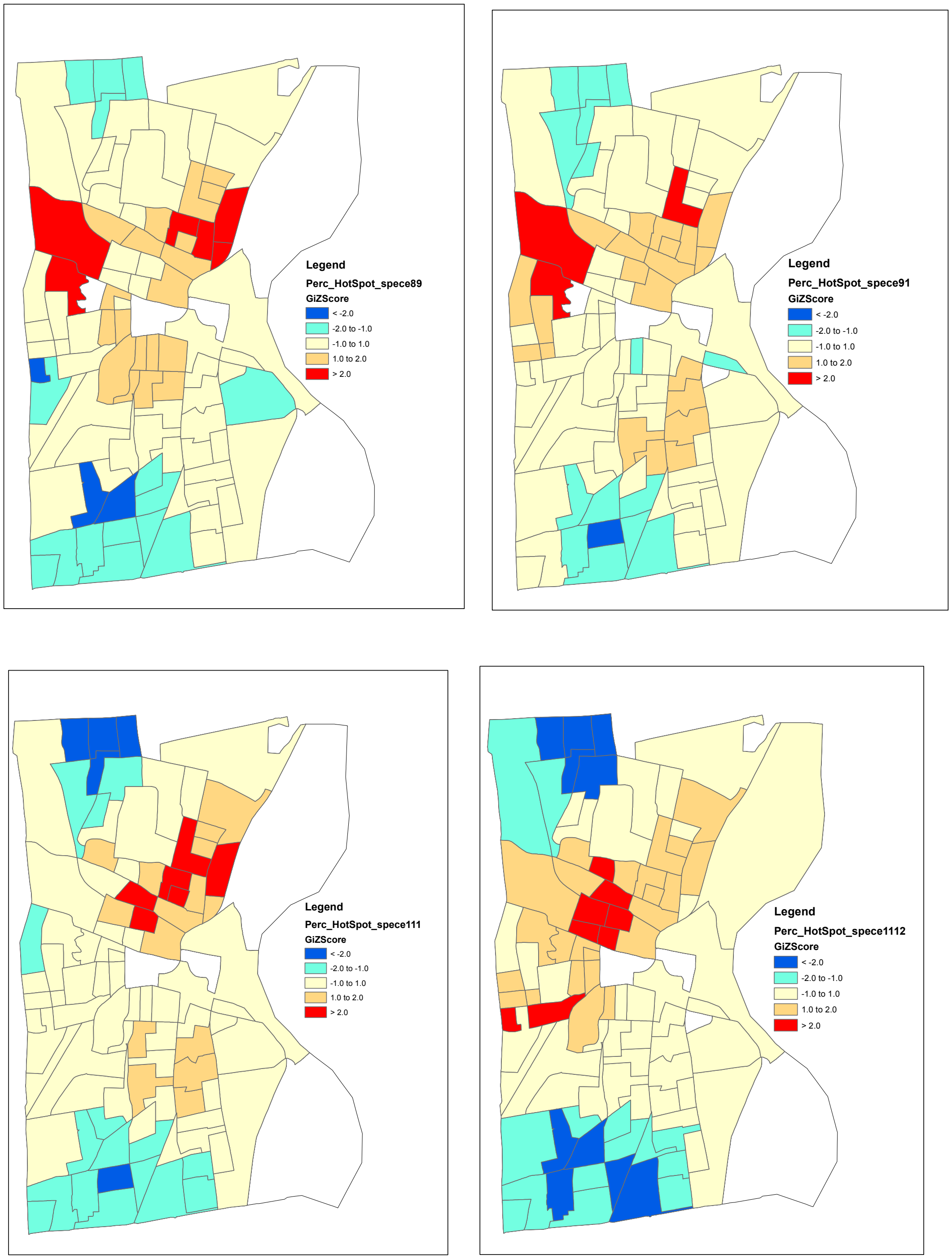
As expected from both the distribution maps of the proportion of black students and the clustering analysis, the North End has both a large number and growing concentration of census block groups with high (and low) proportions of black students- more (and less) than two standard deviation above the mean.

Maps 10: Hot Spot Analysis of Proportion of Black Students, 09-12



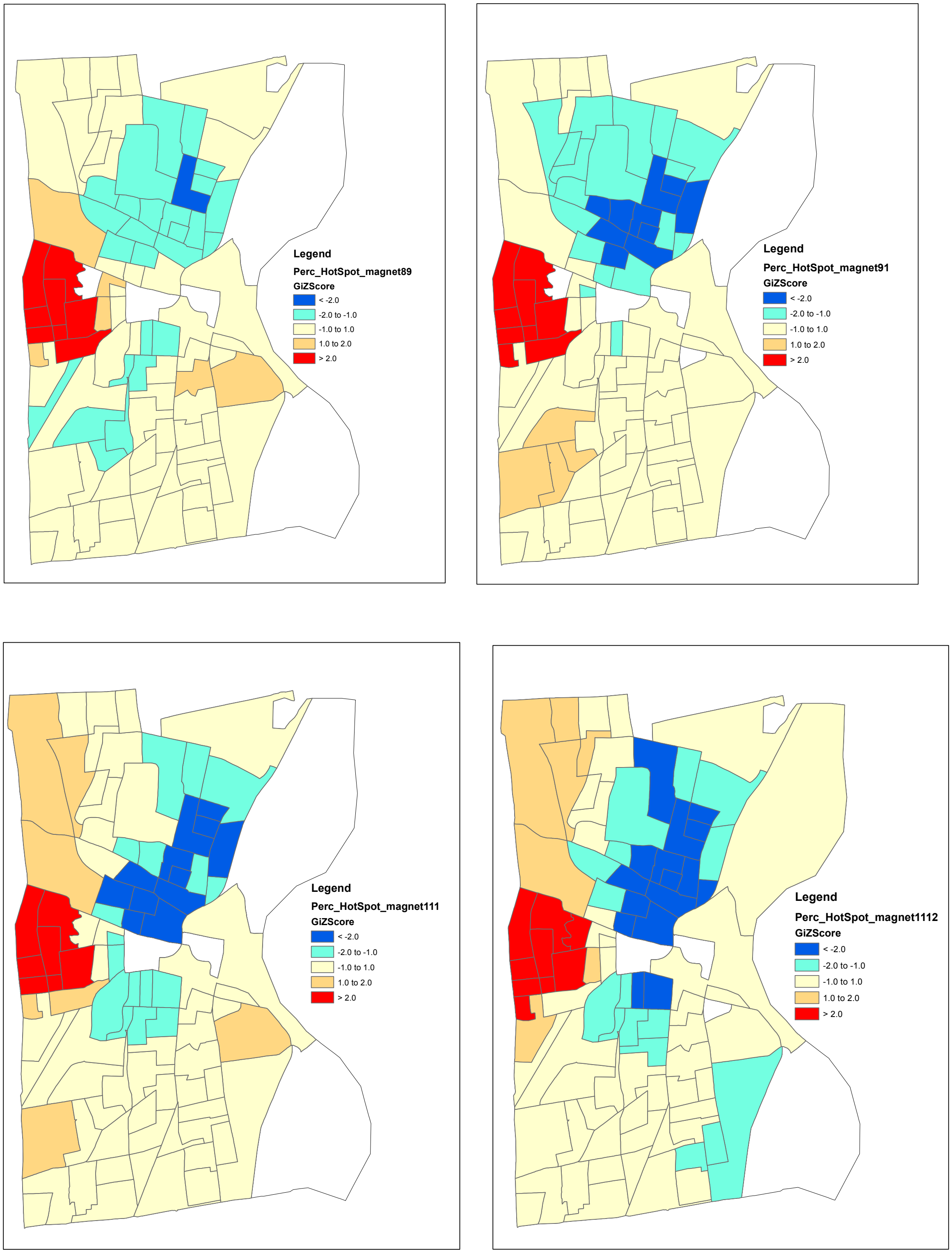
As seen below, by 2011-12 there appears to be a pattern of clusters of low proportions of special needs students in the north-west and south west corners of the City, as well as of high proportions of special education students in the lower northern region of the City.

Maps 11: Hot Spot Analysis of Proportion of Special Education Students, 09-12



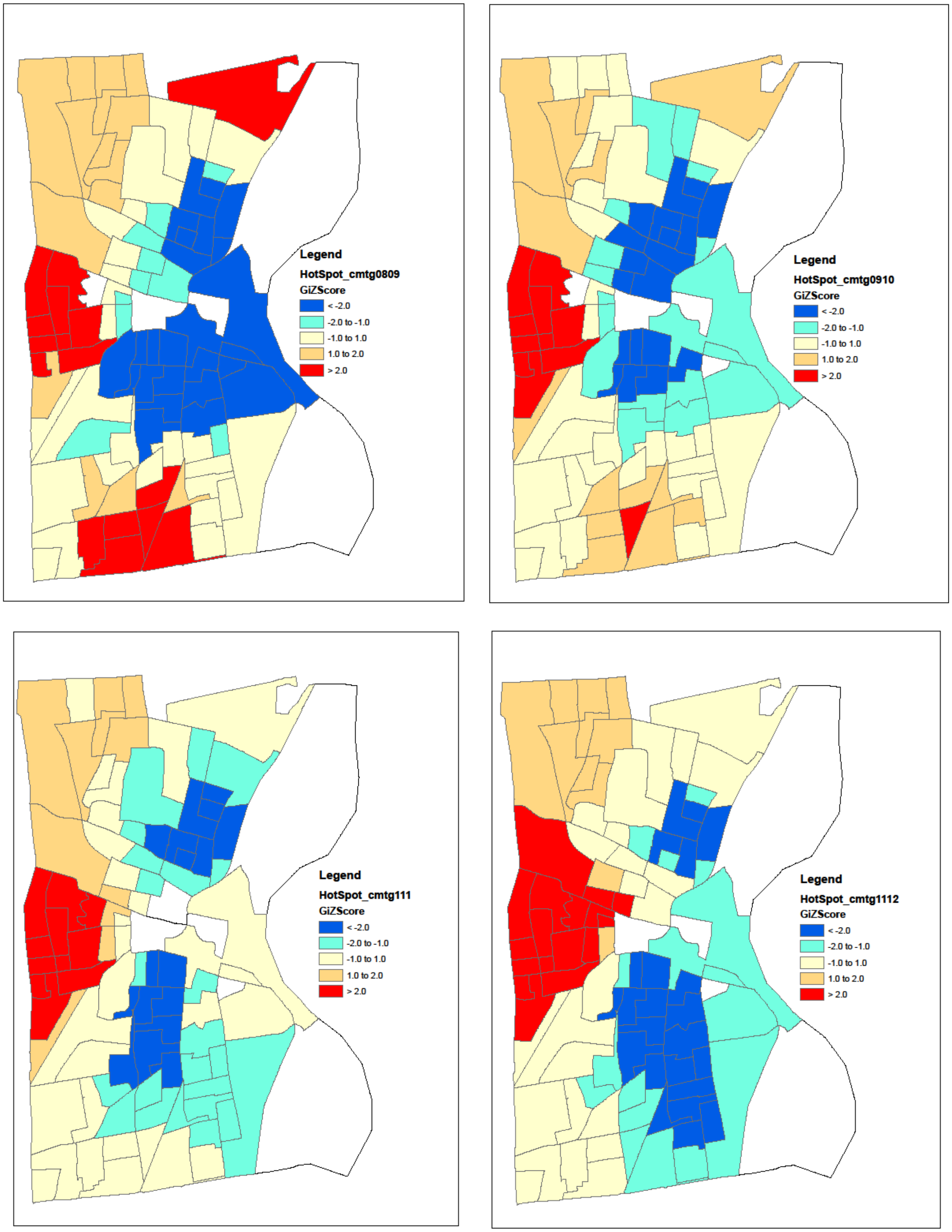
There is clustering of census block groups with high proportions of students attending HPS magnets in the West End and with low proportions in the central North End.

Maps 12: Hot Spot Analysis of Proportion of HPS Magnet Students, 09-12



Over the four years there are fewer regions where students live who attend schools with very high school CMT scores (two standard deviations above the mean). These students are clustered in the mid-western region of the City.

Maps 11: Hot Spot Analysis of Proportion of Average CMT Scores of Student's School, 09-12



Note on Collaboration and Acknowledgements: This report is a result of collaborative work by Trinity faculty, staff, students, and community partners. Professor Diane Zannoni (Economics) and Jack Dougherty (Educational Studies) co-designed the study and co-wrote the text of the report. Jack obtained and geocoded the data, and Diane conducted the data analysis and supervised student researchers. Instructional technologists Sue Denning and David Tatem assisted with data migration and map creation. Trinity students Ned Hurwitch '13 and Jenna Wilborne '15 joined data and created maps, and Marissa Block '14, Gaurav Toor '14, and Stephen Spirou '15 updated the analysis. We appreciate the cooperation of the Hartford Public Schools staff (particularly George Michna and Shayne Reed) for providing student-level data, and many individuals who helped us to learn more about spatial analysis (especially Andy Anderson) and offered feedback on our work-in-progress.

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