Spatial Exploratory Data Analysis: Enviornmental Justice Index

Thesis for a Master of Public Health, Epidemiology

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Purpose Statement

This fill acts as an extension to the `Exploratory Data Analysis: Enviornmental Justice Index` by examining the spatial components. Given the nature of the data, an examination of the spatial components is required. Specifically, this document will pull from two sources to help with the writing of the code: Ch 7.6 and 7.7 in Analyzing US Census Data: Methods, Maps, and Models in R (link) and Manny Gimond's A basic introduction to Moran's I analysis in R (link).

The examination of the spatial components include: Moran's I calculation with Monte Carlos Simulation, Moran's Scatterplot, Local Spatial Autocorrelation with Getis-Ord local G_i^*, and Hot/Cold Spot Identification.

Definitions:

- **Moran's I**: Moran's I is a measure of spatial autocorrelation, quantifying the degree to which a variable is similarly distributed across neighboring geographic areas. It ranges from -1 (indicating perfect dispersion) to +1 (indicating perfect clustering), with values around 0 suggesting a random spatial pattern. It is used to detect and measure the presence of spatial autocorrelation, helping analysts understand whether the spatial distribution of a variable is clustered, dispersed, or random.
- **Monte Carlo Simulations**: Monte Carlo simulation is a computational technique that uses repeated random sampling to estimate the statistical properties of a system. It is used in tandem with Moran's I calculation to assess the significance of observed spatial autocorrelation by comparing it to the distribution of Moran's I values generated under the null hypothesis of spatial randomness. This is preformed as suggested by Gimond.
- **Moran's Scatter Plot**: Moran's scatterplot is a graphical representation that illustrates the relationship between a variable's values and the spatially lagged values of the same variable, used to visualize spatial autocorrelation. The plot typically includes a 45-degree reference line and divides the data points into four quadrants to help identify patterns of clustering or dispersion. It is used to diagnose and visualize spatial autocorrelation, helping to identify patterns of spatial clustering or dispersion in a dataset.
- **Local Spatial Autocorrelation**: Local measures of spatial autocorrelation, like the Getis-Ord local G_i^*, are used to identify clusters or "hot spots" of similar values within a spatial dataset. The Getis-Ord local G_i^* statistic specifically measures the degree of clustering of high or low values around each point, indicating areas with significant local spatial association.
  - *Positive Gi Values*: indicate areas where high values of rpl_themes are surrounded by other high values, or low values are surrounded by other low values. This suggests clustering of similar values.
  - *Negative Gi Values*: Indicate areas where high values of rpl_themes are surrounded by low values, or vice versa. This suggests spatial outliers or contrast.

Morans I Calculation and Scatter Plot

At $\alpha = 0.05$, all variables are statistically significant. Only one that had a statistic close to zero,the estimated number of persons in group quarters (`e_groupq`). All other variables had higher Moran's I values that what was foud in the SVI. The variables with the top 3 highest moran's i value include the annual mean days above PM2.5 regulatory standard (3 yr avg) (`e_pm`), the probability of Contracting Cancer (assuming continuous exposure) (`e_totcr`), and the ambient concentrations of diesel (PM/m3) (`e_dslpm`). The summary index value remained higher (`rpl_eji`) than what was found for the SVI summary index value. All other statistically significant variables demonstrated weaker presence of spatial autocorrelation, and measures related to coal and mining did were statistically insignificant.

Additionally, a moran's scatterplot was only preformed for the outcome of interest since creating graphs for all variables would provide redundant information. However, these graphs can be made available upon request. In support with the Moran's I calculation with Monte Carlo Simulations, the scatterplot suggests a positive correlation between the SVI Summary Value and its spatial lag, representative of spatial autocorrelation in the data.

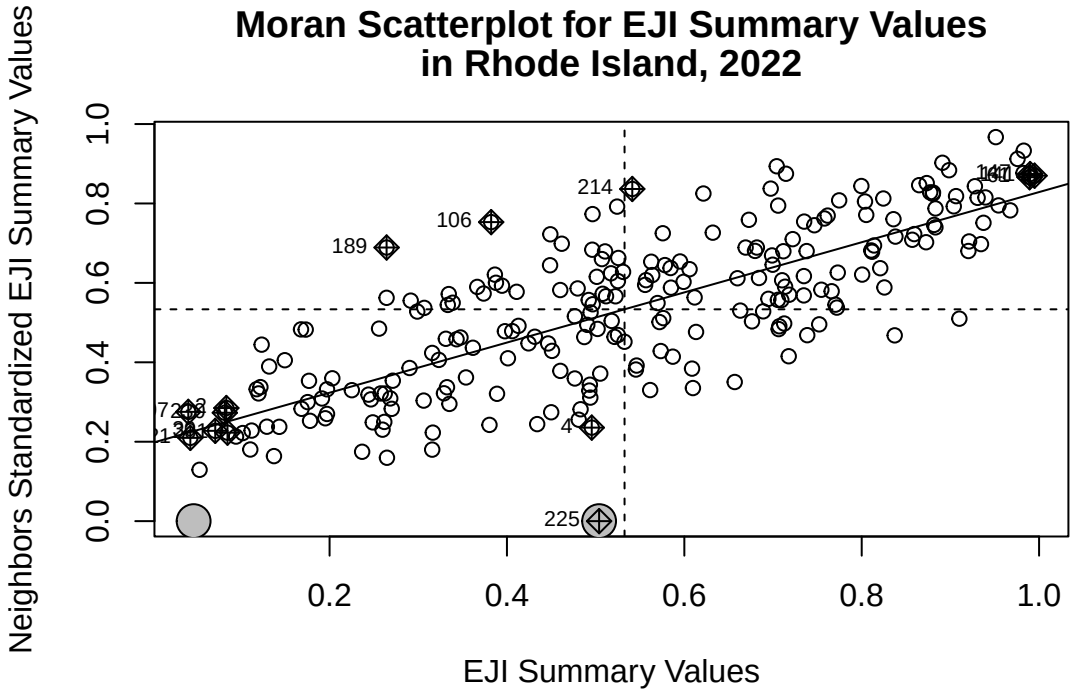
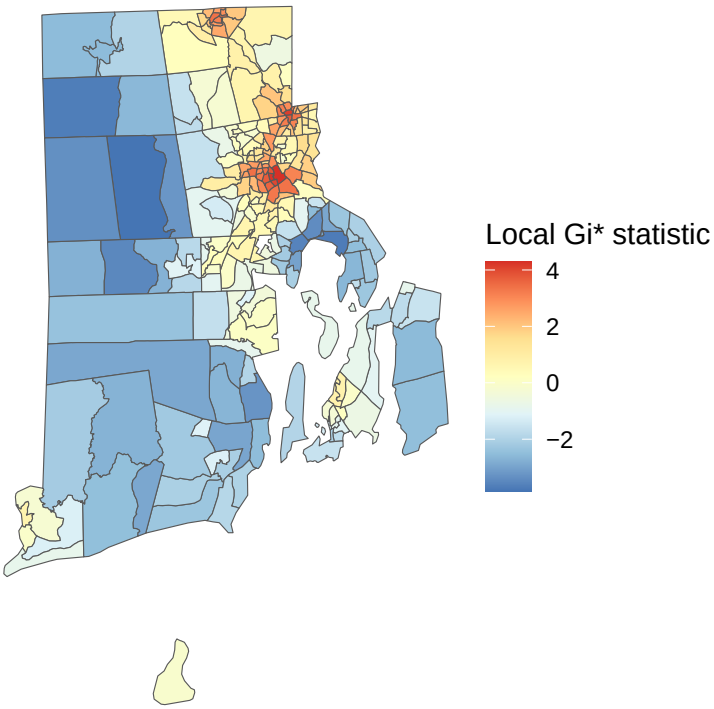


Table 1: Moran's I with Monte Carlo Simulations

variable	statistic	pvalue
e_pm	0.952	0.001
e_totcr	0.908	0.001
e_dslpm	0.877	0.001
e_ozone	0.812	0.001
ep_minrty	0.758	0.001

variable	statistic	pvalue
e_rail	0.755	0.001
e_impwtr	0.738	0.001
ep_limeng	0.707	0.001
e_tri	0.678	0.001
e_wlkind	0.667	0.001
e_park	0.666	0.001
rpl_eji	0.614	0.001
e_road	0.591	0.001
ep_pov200	0.591	0.001
ep_renter	0.591	0.001
e_houage	0.577	0.001
ep_nohsdp	0.553	0.001
ep_asthma	0.532	0.001
e_tsd	0.521	0.001
e_airprt	0.494	0.001
e_rmp	0.481	0.001
ep_uninsur	0.464	0.001
ep_mhlth	0.457	0.001
ep_diabetes	0.441	0.001
ep_houbdn	0.430	0.001
ep_cancer	0.429	0.001
ep_noint	0.386	0.001
ep_age65	0.312	0.001
ep_age17	0.307	0.001
e_npl	0.305	0.001
ep_bphigh	0.280	0.001
ep_unemp	0.233	0.001
ep_disabl	0.220	0.001
ep_mobile	0.176	0.001
ep_groupq	0.081	0.020
e_coal	NaN	0.001
e_lead	NaN	0.001

Local Spatial Autocorrelation with G_i^* & Hot/Cold Spot Identification



Hot Spot for SVI Summary Values