3600 Morrissey Hall Access Code: 1553

Course philosophy

* The result of using the scientific method is NOT absolute truth.
* More interested in your position and opinion rather than just the correct answer.
* Quality of work is more important that arbitrary due dates.
* Course synthesizes statistics and demography.

Trends

* A lot of traditional social science assumes that space doesn’t matter.
* Spatial demography is becoming computational.

Spatial demography

* Creating maps is a prerequisite for developing the spatial model.

Statistics concepts

* Goal is to create dependent variables that are interval or ratio whenever possible.
  + Allows use of the most sophisticated spatial statistics (i.e., high statistical power).
* Distributions
  + Methods are based on normal distribution
  + Real world data is rarely normally distributed
  + Income distribution is an example of positively skewed data (right skewness)
  + High school education is an example of negatively skewed data (left skewness)
* Ideal situation
  + Normal distribution
  + Small standard deviation
  + 68-95-99 rule
* Errors
  + Type I error is error of commission
  + Type II error is error of omission
  + Type II error is preferred to Type I error
  + Type I errors lead to retractions of journal articles
  + U.S. legal system
    - H0: person is NOT guilty (not the same as innocent)
      * Evidence is insufficient to reject the null hypothesis
    - HA: person is guilty
* Generally, cannot achieve a BLUE model.

Demography concepts

* The scientific study of human populations
* Elements of demography
  + Mathematical knowledge of populations
  + General movement of populations
  + The physical, civil, intellectual, and moral state of populations

The Importance of Space

* Y indicates dependent variable
* X indicates independent variable
* The goal is integrating space as part of the model
* More interdisciplinary research
* Many disciplines are afraid of integration of social sciences

Software and Infrastructure

* ArcMap will be going away; will be replaced by ArcPro and ArcGIS online
* QGIS is open source

Spatial Perspectives

* Functional distance
  + Time and effort required to move from point A to point B
  + Often must create additional data
* Spatial position
  + Comparative advantage and disadvantage of one space to another space
  + e.g., location of new MLS stadium
    - St. Charles residents will be the primary users
    - St. Louis City residents will absorb the costs
* Spatial order
  + Spatial hierarchy within a region
  + Relevant to class and stratification

Spatial Data

* Geodatabases are easier to use than shapefiles
* Quality of shapefile is important
* Can produce errors in spatial analysis
* Dr. Sandoval recommends obtaining shapefiles from U.S. Census

Data Sources

* U.S. Census ([www.census.gov](http://www.census.gov))
* Social Explorer ([www.socialexplorer.com](http://www.socialexplorer.com))

Homework

* Choose an MSA region other than St. Louis MSA or choose variables for St. Louis MSA that are different from the lab.
* Dependent variable should be interval/ratio or dichotomous.

Lab Procedure

* Download data from SocialExplorer.com
  + Click on Tables menu item
  + Click on the ACS 5-year estimates (2014-2018)
  + Click on Begin Report
  + For the geographic type, select Census Tract (140)
  + Select the states of interest
  + For geographic area, select All Census Tracts in the state
  + Click Add
  + Click Proceed to Table
  + Select tables to download
    - A02001 Sex
    - A01001 Age
    - A04001 Hispanic or Latino by Race
    - A14028 Gini index of income inequality
  + Click Add
  + Click Show Results
  + Download for files STATA
    - Tab delimited data
    - STATA .dct file (i.e., dictionary for how to read text files)
    - STATA .do file (i.e., program)
    - Data dictionary .txt file
  + Download for RStudio
    - Comma separated data .csv file
    - Data dictionary .txt file
  + Treat the category Hispanic or Latino as a race
* Creating ratio variables using STATA
  + Double click .do file (i.e., R12432906) to open it
  + \* used to add comments
  + Add folder file path in front of .txt filename in code
  + Add code before infile line code
    - Add line code capture log close
    - Add line code set more off
    - Add line code clear
  + Add code after infile line code
    - Add line code log using analysis.log, replace
  + Copy code for calculating ratio variables from lab .do file on Blackboard
  + Paste code for calculating ratio variable into .do file from data download
    - After line code log using analysis.log, replace
  + Change folder file path in
    - line code for exporting to Excel file
    - line code for creating new STATA database
  + Run program
    - Control-A to highlight the program
    - Click Execute selection(do) menu button
  + Creates new files in lab01/data folder
    - part01.xls
    - stl\_part01.dta
* Download base shapefiles
  + Download shapefiles from U.S. Census using TIGER/line shapefiles database
    - 2019 ACS 5-year estimate
  + Export ZIP files into lab01/data subfolders named for each shapefile
    - Illinois Census tract 17 (tl\_2019\_17\_tract)
    - Missouri Census tract 29 (tl\_2019\_29\_tract)
    - Entire USA (tl\_2019\_us\_cbsa)
* Create new shapefile in ArcGIS
  + Open new map in ArcMap
  + Add each shapefile as a layer
    - tl\_2019\_17\_tract (i.e., Illinois)
    - tl\_2019\_29\_tract (i.e., Missouri)
    - tl\_2019\_us\_cbsa (i.e., entire USA)
  + Create new file geodatabase in lab01 folder
    - Right Click on folder 🡪 New 🡪 File Geodatabase
    - Rename geodatabase (e.g., lab01)
  + Merge Illinois and Missouri shapefiles
    - Select layers for Illinois and Missouri to activate them
    - Deactivate layer for Entire USA
    - Geoprocessing 🡪 Merge
    - Drag and drop Illinois and Missouri layers
    - Set output file path to newly created file geodatabase
    - Enter name for new shapefile (e.g., states01)
      * Use feature class file type
  + Select Entire USA shapefile layer to activate it
    - Deactivate other layers
  + Export St. Louis MSA shapefile
    - Select tract
    - Right click on layer 🡪 Data 🡪 Export Data
    - Export to file geodatabase
    - Name shapefile (e.g., stl\_msa)
      * Use file and personal geodatabase feature class file type
  + Clip census track shapefile to St. Louis MSA shapefile
    - Select stl\_msa shapefile layer
    - Select states01 shapefile layer with census tracts
    - Geoprocessing 🡪 Clip
    - Input feature is states01
    - Clip feature is stl\_msa
    - Output to file geodatabase
    - Name shapefile (e.g., stl\_msa\_ct\_00)
      * Use feature class file type
      * GEOID is unique to each case
  + Merge ratio variables data created using STATA into shapefile for St. Louis MSA
    - Select St. Louis MSA census tracts shapefile layer (stl\_msa\_ct\_00) to activate it
      * Deactivate all other layers
    - Add ratio variables data as a new layer
      * Click on Add Data button
      * Select part01.xls file
      * Select Sheet1$
    - Right click on St. Louis MSA census tracts shapefile layer (stl\_msa\_ct\_00)
      * Join and Relates 🡪 Join
      * Choose GEOID as the basis for the shapefile layer
      * Choose Sheet1$ as the table
      * Use FIPS as the basis for the table
      * Validate join (optional)
      * Click OK
  + Convert to permanent shapefile
    - Right click on St. Louis MSA census tracts shapefile layer (stl\_msa\_ct\_00)
    - Data 🡪 Export Data
    - Output to file geodatabase
    - Name shapefile (stl\_msa\_ct\_01)
    - Select type “File and Personal Geodatabase feature classes”
    - Click OK

ArcMap

* Fragile software; has integrity issues.
* Restart the computer if the software becomes unstable and starts crashing a lot.

Education Attainment

* The amount of education attainment of a region.
* Flexibility with how trade school education is handled.
* Individuals still seeking education are not counted in the index.

Income Inequality

* Can apply concept to other topics such as education.

Gini Concentration Ration

* Measure area of inequality in Lorenz curve.
* Calculated as part of Social Explorer data.

Theil Index

* More powerful than the Gini Concentration Ratio
  + Better mathematical properties.
  + Additive across different subgroups or regions.
  + Local scores add up to global score.
* Not used very often.
* Difficult to interpret.
* Part of General Entropy class which is a family of measures.

Creating Index

* Rescale individual components (i.e., variables) on 0 to 1 scale.
* Default is that each variable gets the same weight.

Class Project

* Creating index for project is optional.

Lab Procedure

* NOTE: Create data dictionary for newly generated shapefiles.
* Creating Excel file (part02.xls) with additional demographic data
  + Download folder lab02
  + Double click the downloaded .do file with the downloaded tract level demographic data (i.e., R12438420) in STATA to open it.
  + Change the file path in front of the .txt filename in the infile line code (line 11).
  + Change the file path in front of the .xls filename in the export function line code (line 152).
  + Change the file path in front of the .dta filename in the save function line code (line 154).
  + Run program
    - Control-A to highlight the program
    - Click the Execute(do) menu button
* Add additional demographic data to shapefile stl\_msa\_ct\_01
  + Open stl\_msa\_ct\_01 shapefile in ArcMap and select it as an active layer.
    - Deactivate all other layers.
  + Click the Add Data button.
  + Add Sheet$1 of part02.xls as a layer and select it as an active layer.
  + Join the Excel data to the shapefile.
    - Highlight and right click on stl\_msa\_ct\_01
    - Select Join and Relates
    - Select Join
    - Select GEOID as the shapefile field on which to base the join.
    - Select Sheet$1 as the data layer for joining.
    - Select FIPS as the data field on which to base the join.
    - Click on Validate Join to check (optional).
    - Click OK
  + Save as new permanent shapefile to the file geodatabase.
    - Highlight and right click on stl\_msa\_ct\_01
    - Select Data
    - Select Export Data
    - Select the file geodatabase (lab01.gdb) as the output location.
    - Name the shapefile stl\_msa\_ct\_02
    - Select type “File and Personal Geodatabase feature classes”
    - Click OK
* Remove census tracts that will skew results.
  + Add stl\_msa\_ct\_02 as a new layer in ArcMap.
    - Deactivate all other layers.
  + Add a new variable named Keep in the attributes table.
    - Right click on the layer.
    - Select Open Attributes
    - Select Add Field from the drop down menu
    - Name the field “Keep”
  + Set default value for the Keep variable
    - Highlight the Keep variable column in the attributes table.
    - Right click and select Field Calculator
    - Enter “1” in the Keep = formula box (where 1 means “yes”)
    - Click OK
  + Identify census tracts to eliminate and remove them
    - Activate the shapefile layer stl\_msa\_ct\_02
    - Select Customize drop down menu
    - Select Toolbars
    - Select Editor
    - Select Start Editing
    - Select the census tracts to eliminate with the selector
    - Right click on the census tract
    - Select Delete Polygon
    - Click Save
    - Select Stop Editing
  + Save the new shapefile to the gis folder.
    - Highlight and right click on modified stl\_msa\_ct\_02 layer
    - Select Data
    - Select Export Data
    - Select the Labs/data/gis folder as the output location.
    - Name the shapefile stl\_ct
    - Select type “Shapefile”
    - Click OK
* Create indexes for statewide data
  + Open gis.do file from the Labs/data/gis folder in STATA
  + Change the file path in line code 3 to the Labs/data/gis folder
  + Run program
    - Control-A to highlight the program
    - Click the Execute(do) menu button
  + Open merge\_final.do file from the Labs/data/lab02 folder in STATA
  + Change the file path in line code 4, 8, 10, and 14
  + Run program lines 1-31
    - Highlight the program code
    - Click the Execute(do) menu button
  + Insert the table from the output after line code 31
  + Replace the minimum and maximum values for the Theil index in the merge\_final.do file
  + Change the file path in the remainder of the program
    - Line code 66
    - Line code 68
  + Run the remainder of the program
    - Highlight the program code
    - Click the Execute(do) menu button
* Add indexes to modified shapefile
  + Open stl\_ct shapefile in ArcMap and select it as an active layer.
    - Deactivate all other layers.
  + Click the Add Data button.
  + Add Sheet$1 of final.xls as a layer and select it as an active layer.
  + Join the Excel data to the shapefile.
    - Highlight and right click on stl\_ct
    - Select Join and Relates
    - Select Join
    - Select GEOID as the shapefile field on which to base the join.
    - Select Sheet$1 of final.xls as the data layer for joining.
    - Select FIPS as the data field on which to base the join.
    - Click on Validate Join to check (optional).
    - Click OK
  + Save the new shapefile to the file geodatabase.
    - Highlight and right click on stl\_ct
    - Select Data
    - Select Export Data
    - Select the file geodatabase (lab01.gdb) as the output location.
    - Name the shapefile stl\_msa\_ct\_03
    - Select type “File and Personal Geodatabase feature classes”
    - Click OK
* Add projection to the shapefile data
  + Open stl\_msa\_ct\_03 shapefile in ArcMap and select it as an active layer.
    - Deactivate all other layers.
  + Click on the ArcToolbox menu icon
  + Select Data Management Tools
  + Select Projections and Transformations
  + Select Project
  + Select stl\_msa\_ct\_03 shapefile as the input
  + Select the file geodatabase (lab01.gdb) as the output location
  + Name the shapefile stl\_msa\_ct\_04
  + Select UTM-15 for the output coordinate system.
  + Click OK
* Activate projection in current ArcMap project
  + Go to layout view
  + Right click and select Properties
  + Select Coordinate System tab
  + Change projection coordinate system to NAD 1983 UTM-15
  + Save changes

Homework

* Select city with at least 250,000 people or MSA with at least 500,000 people.
* Only include census tracks with at least 100 people.
  + All other variables should be okay.
* Additional social data available at PolicyMap
  + Access through SLU Pius XII Memorial Library under databases

Lecture on Geographic Distribution

* Technique of exploratory spatial analysis.
* Spatial variation
  + Non-spatial models may not be valid.
  + Models that apply in one locality are unlikely to be applicable in another locality.
* Why geographic distribution is examined.
  + Identify the center
  + Determine shape and orientation of data
  + Understand the dispersion of the features
* Three Kinds of Center
  + Mean 🡪 average x-y coordinate for all features
  + Median 🡪 x-y coordinate with shortest distance to all features
  + Central Feature 🡪 feature that has the shortest total distance to all other features
* Weighted mean center
  + Not every case should be treated the same
    - land value
    - distinguishing between degrees of poverty
    - different types of crime
  + Sensitive to outliers
* Median center
  + No single equation to calculate median center
  + Approximated by software through iterative calculation
  + Tends to gravitate toward areas with the most features
* Central feature
  + Sum the distance to all other features for each feature.
  + Select the feature with the shortest distance.
* Measuring concentration and dispersion
  + Default is to use one standard deviation when the boundary is known.
  + Use three standard deviation when we don’t know the boundary.
  + Standard distance
  + Standard deviational ellipse (SDE)
* A central city is a heavily populated city at the center of a large metropolitan area [*Central City*. (n.d.). Oxford Dictionary. Retrieved February 6, 2020 from https://www.google.com/search?client=firefox-b-d&q=what+is+a+central+city].
  + Defined and designated by the U.S. Census bureau.
  + There are three central cities (cc) in the St. Louis region.
    - St. Charles, MO
    - City of St. Louis, MO
    - East St. Louis, IL

Lab Procedure

* Ensure that spatial analysis extensions in ArcMap are activated
  + Select Customize dropdown menu
  + Select Extensions
  + Select the extensions you want to activate
  + Click Close
* Create file geodatabase subfolder to organize data from exploratory spatial analysis (ESA)
  + Right click on file geodatabase (i.e., lab.gdb)
  + Select New
  + Select Feature Dataset
  + Name feature dataset (e.g., “esa”)
  + Click Next
  + Select the coordinate system (e.g., NAD 1983 UTM-15)
  + Click Next
  + Click Next to skip the z-coordinate settings
  + Modify XY tolerance settings if necessary (generally, should not be necessary)
  + Click Finish
* Access functions for measuring geographic distribution
  + Select Geoprocessing dropdown menu
  + Select ArcToolbox
  + Select Spatial Statistics Tools
  + Select Measuring Geographic Distributions
* Create shapefiles for mean center
  + Add and activate base layer (i.e., stl\_msa\_ct\_04) for new map in ArcMap
  + Select Geoprocessing dropdown menu
  + Select ArcToolbox
  + Select Spatial Statistics Tools
  + Select Measuring Geographic Distributions
  + Select Mean Center
  + Select stl\_msa\_ct\_04 as the input feature class
  + Select the esa subfolder in the file geodatabase (i.e., lab.gdb/esa) as the output feature class
  + Enter name for the new shapefile (e.g., mc\_wht)
  + Set type to Feature classes
  + Click Save
  + Select the variable upon which to base the calculation (e.g., wht) in Weight Field (optional)
  + Click OK
  + Repeat for other groups as necessary
  + Obtain XY coordinates from attribute table
* Create shapefiles for standard distance
  + Add and activate base layer (i.e., stl\_msa\_ct\_04) for new map in ArcMap
  + Select Geoprocessing dropdown menu
  + Select ArcToolbox
  + Select Spatial Statistics Tools
  + Select Measuring Geographic Distributions
  + Select Standard Distance
  + Select stl\_msa\_ct\_04 as the input feature class
  + Select the esa subfolder in the file geodatabase (i.e., lab.gdb/esa) as the output feature class
  + Enter name for the new shapefile (e.g., sd\_wht)
  + Set type to Feature classes
  + Click Save
  + Select desired standard deviation for Circle Size (e.g., 1\_Standard\_Deviation)
  + Select the variable upon which to base the calculation (e.g., wht) in Weight Field (optional)
  + Click OK
  + Repeat for other groups as necessary
  + Obtain area value from attribute table
  + Create new variable to convert shape area to desired units (optional)
    - Open attribute table
    - Click drop down menu
    - Select Add Field
    - Enter name of field (e.g., area-km)
    - Select the kind of value for Type (e.g., Double)
    - Click OK
    - Right click on the newly added field (variable)
    - Select Calculate Geometry…
    - Select the value to calculate in Property
    - Select the units to use in Units
    - Click OK
* Create shapefiles for standard deviational ellipses (i.e., standard distance taking into consideration geographic features such as rivers and lakes)
  + Add and activate base layer (i.e., stl\_msa\_ct\_04) for new map in ArcMap
  + Select Geoprocessing dropdown menu
  + Select ArcToolbox
  + Select Spatial Statistics Tools
  + Select Measuring Geographic Distributions
  + Select Directional Distribution (Standard Deviational Ellipse)
  + Select stl\_msa\_ct\_04 as the input feature class
  + Select the esa subfolder in the file geodatabase (i.e., lab.gdb/esa) as the output feature class
  + Enter name for the new shapefile (e.g., sde\_wht)
  + Set type to Feature classes
  + Click Save
  + Select desired standard deviation for Circle Size (e.g., 1\_Standard\_Deviation)
  + Select the variable upon which to base the calculation (e.g., wht) in Weight Field (optional)
  + Click OK
  + Repeat for other groups as necessary
  + Obtain area value and rotation from attribute table
    - Rotation is measured counterclockwise
  + Create new variable to convert shape area to desired units (optional)
    - Open attribute table
    - Click drop down menu
    - Select Add Field
    - Enter name of field (e.g., area-km)
    - Select the kind of value for Type (e.g., Double)
    - Click OK
    - Right click on the newly added field (variable)
    - Select Calculate Geometry…
    - Select the value to calculate under Property
    - Select the units to use under Units
    - Click OK

Lecture Notes

Announcements

* No class next Thursday, February 20, 2020
* Can replicate lab for a different city for Homework 01
* Poverty rate can be used as a dependent variable for Homework01 and Class Project

Spatial Interpolation with Grids

* Interpolation is an estimate.
* Administrative boundaries don’t match social boundaries.
* Administrative boundaries may change over time.
* Used to standardize variables.

Modifiable Areal Unit Problem

* Recommendation to no longer use ZIP code data.
  + Will likely result in a Type I error.
* Problems
  + Scale (i.e., aggregation)
  + Grouping (i.e., Zones)
  + Ecological fallacy
* Generally, the larger the spatial units the stronger the relationship among variables.
* Spatial units are arbitrarily defined; different definitions may introduce biases in the analysis.
* Ecological fallacy is that aggregated results are applied to individuals.
* Solutions
  + Normalize boundaries to a specific administration definition of spatial units (e.g., year 2000 census tract boundaries to year 2010 census tract boundaries).
  + Normalize boundaries to standard space (e.g., grid)

Making a Grid

* The smaller the spatial unit the more accurate the data.
* General rule is to use the most accurate data available
  + e.g., census block data are preferred to census tract data they contain the data for the variable of interest.

Lab Procedure

Create file geodatabase subfolder to organize workflow for grid interpolation

* Right click on file geodatabase (i.e., lab.gdb)
* Select New
* Select Feature Dataset
* Name feature dataset (e.g., “grid”)
* Click Next
* Select the coordinate system (e.g., NAD 1983 UTM-15)
* Click Next
* Click Next to skip the z-coordinate settings
* Modify XY tolerance settings if necessary (generally, should not be necessary)
* Click Finish

Create subfolder in file geodatabase for workflow

* Right click on file geodatabase (i.e., lab.gdb)
* Select New
* Select Feature Dataset
* Name feature dataset (e.g., “grid”)
* Click Next
* Select the coordinate system (e.g., NAD 1983 UTM-15)
* Click Next
* Click Next to skip the z-coordinate settings
* Modify XY tolerance settings if necessary (generally, should not be necessary)
* Click Finish

Define study area

* Start new project in ArcMap
* Add base layer shapefile (e.g., stl\_msa\_ct\_04)
* Right click on layer
* Select Attribute Table
* Sort by COUNTYFP
* Select rows for the City of St. Louis (e.g., COUNTYFP 510)
* Right click on layer
* Select Properties
* Select Defintion Query tab
* Click on Query Builder
* Double click COUNTYFP
* Set COUNTYFP = ‘510’
* Click OK
* Click on Geoprocessing drop down menu
* Select Dissolve
* For Input Feature Class, select the shapefile for the study area (e.g., stl\_msa\_ct\_04)
* For Output Feature Class, select the subfolder in the file geodatabase (e.g., lab/grid)
* Enter name for the new shapefile (e.g., stl\_city)
* Click Save

Create grid

* Add new shapefile for study area as the active layer (e.g., stl\_city)
  + Deactivate any other layers
* Click on Geoprocessing drop down menu
* Select ArcToolbox
* Select Cartography Tools
* Expand Data Driven Pages
* Double click Grid Index Features
* For Output Feature Class, select the subfolder in the file geodatabase (e.g., lab/grid)
* Enter name for the new shapefile (e.g., stl\_grid01)
* Click Save
* For the unit of measure (Polygon Width and Polygon Height), select Meters
* For Polygon Width, enter the desired dimension (e.g., 1000)
* For the Polygon Height, enter the desired dimension (e.g., 1000)
* Click OK

Clip grid to study area boundary

* Click on Geoprocessing drop down menu
* Select Clip
* For Input Feature Class, select the shapefile for grid (e.g., stl\_grid01)
* For Clip Features, select the shapefile for the study area (e.g., stl\_city)
* For Output Feature Class, select the subfolder in the file geodatabase (e.g., lab/grid)
* Enter name for the new shapefile (e.g., stl\_grid02)
* Click Save

Clean partial grids to remove from analysis

* Add and activate base layer shapefile (e.g., stl\_grid02)
  + Deactivate all other layers
* Select the Customize drop down menu
* Select Toolbars
* Select Editor
* Select Start Editing
* Right click on layer
* Select Open Attributes Table
* Sort on the Shape\_Area variable
* Select rows with partial grids less than designated threshold (e.g., 50,000 square meters)
* Right click on selected rows
* Select Delete Selected
* Select Save Edits
* Select Stop Editing
* Click on Geoprocessing drop down menu
* Select Intersect
* For Input Feature Class, add the features to intersect
  + The shapefile for grid (e.g., stl\_grid02)
  + The shapefile for the census tracts (e.g., stl\_msa\_ct\_04)
* For Output Feature Class, select the subfolder in the file geodatabase (e.g., lab/grid)
* Enter name for the new shapefile (e.g., stl\_int01)
* Click Save

Prepare to interpolate census tract data to grid

* Add and activate base layer shapefile (e.g., stl\_int01)
  + Deactivate all other layers
* Right click on layer
* Select Open Attributes Table
* Click on drop down menu
* Select Add Field
* Enter name for new variable (e.g., area)
* Select Double for type
* Click OK
* Highlight the column for the new variable
* Right click on the column
* Select Calculate Geometry
* Verify that it defaults to the correct coordinate system
* Select the desired unit of measure (e.g., square kilometers)
* Click OK
* Click on drop down menu
* Select Add Field
* Enter name for second new variable (e.g., area\_wgt)
* Select Double for type
* Click OK
* Click on drop down menu
* Select Add Field
* Enter name for third new variable (e.g., pop\_new)
* Select Double for type
* Click OK
* Decide on variable to use that is unique to the census tracts (e.g., GEOID)
* Highlight the column for the unique variable
* Right click on the column for the unique variable
* Select Summarize
* Verify that the selection field defaulted to the unique variable (e.g., GEOID)
* Select the summary statistics
  + First new variable (i.e., area)
    - Sum
* For Output Table, you can leave the default (Sum\_Output)
* Click OK
  + Add the result table to the map
* Right click on the working layer (e.g., stl\_int01)
* Select Join and Relates
* Select Join Data
* Select GEOID as the field in the layer upon which the base the join
* Select the result table (e.g., Sum\_Output) as the table for joining
* Select GEOID as the field in the table upon which to base the join
* Click Validate Join (optional)
* For Join Options, select keep all records
* Click OK
  + Sum\_Area variable has been added to the working layer (e.g., stl\_int01)
* Right click on layer
* Select Data
* Select Export Data
* For Output Feature Class, select the subfolder in the file geodatabase (e.g., lab/grid)
* Enter name for the new shapefile (e.g., stl\_int02)
* Click Save

Finishing interpolating census tract data to grid

* Add and activate base layer shapefile (e.g., stl\_int02)
  + Deactivate all other layers
* Right click on layer
* Select Open Attributes Table
* Highlight the column for the second new variable created (e.g., area\_wgt)
* Right click on the column for the variable
* Select Field Calculator
* Enter formula
  + area\_wgt = area / Sum\_area
* Click OK
* Highlight the column for the third new variable created (e.g., pop\_new)
* Right click on the column for the variable
* Select Field Calculator
* Enter formula
  + pop\_new = area\_wgt \* tot
* Click OK
* Check data
  + Sort on GEOID
  + Highlight rows for one GEOID
  + Right click on area\_wgt header
  + Select Statistics
  + Verify that area\_wgt for census tract (e.g., same GEOID) sums to one
  + Right click on pop\_new header
  + Select Statistics
  + Verify that pop\_new variable for census tract (e.g., same GEOID) sums to same value for tot variable of the census tract
* Highlight the PageNumber variable column
* Right click on the column
* Select Summarize
* Verify that the selection field defaulted to the unique variable (e.g., PageNumber)
* Select the summary statistics
  + i.e., pop\_new variable
    - Sum
* For Output Table, you can leave the default (Sum\_Output\_2)
* Click OK
  + Add the result table to the map
* Activate desired layer for interpolation (e.g., stl\_grid02)
* Right click on the layer
* Select Join and Relates
* Select Join Data
* Select PageNumber as the field in the layer upon which to base the join
* Select the result table (e.g., Sum\_Output\_2) as the table for joining
* Select PageNumber as the field in the table upon which to base the join
* Click Validate Join (optional)
* For Join Options, select keep all records
* Click OK
  + Sum\_pop\_new variable has been added to the layer (e.g., stl\_grid02)
* Right click on layer
* Select Data
* Select Export Data
* For Output Feature Class, select the subfolder in the file geodatabase (e.g., lab/grid)
* Enter name for the new shapefile (e.g., stl\_grid03)
* Click Save

Lecture

Spatial Statistics for Spatial Data

* The assumption of spatial randomness is almost never true of the data that has been used in classical statistical analysis.
* Classical statistical modeling answers the question how much of a relationship?
  + Assumes spatial randomness.
* Spatial statistical modeling answers the question how much of a relationship where?
  + Identify spatial patterns.

Spatial Autocorrelation

* The correlation of a variable with itself through space.
  + Must be able to see it on a map.
* Four distinct approaches to defining spatial autocorrelation:
  + Geography
    - Tobler’s first law of geography
    - Near things are more related than distant things.
      * e.g., gentrification
  + Similarity
    - Positive spatial autocorrelation manifests as a clustering pattern.
    - Negative spatial autocorrelation manifests as a checker board pattern.
  + Probability
    - The occurrence of an event in one geographic location makes the occurrence of a similar event in a neighboring geographic location more or less probable.
  + Correlation
    - The correlation between the same attribute at two locations.

Importance

* Evidence of the potential existence of a spatial process.
* Invalidates most traditional statistical inference tests.
  + Introduces bias in classical statistical analysis.
  + Increases the probability of making a Type I error.
* Impact on classical statistical inference.
  + Over-estimates the degree of correlation (i.e., value of coefficients).
  + More likely to find a statistically significant relationship where there is none.

Defining nearness of observations

* Conceptual approaches
  + Common borders
  + Radial boundary
* Must be able to defend methodological choices.
* Contiguity
  + First order 🡪 nearest neighbor
  + Second order 🡪 next nearest neighbor

Null Hypothesis When Testing for Spatial Autocorrelation

* H0: The values associated with the geographic features in one location in the study area DO NOT depend on values associated with geographic features in other locations in the study area.
* Failing to reject null hypothesis means that there is no spatial autocorrelation.
  + Simplifies workflow.
  + Can continue with classical statistical inference tests.

Measuring Spatial Autocorrelation

* Moran’s I is a first regression analysis.
* Regressing a variable on itself.
  + Does the dependent variable predict itself?
* The slope of the regression is the Moran’s I value.
* Variable must be interval-ratio
  + Cannot use dichotomous variable.

Lab Procedure

Method 1: ArcMap

* Add and activate map layer (e.g., ct\_04)
* Click on Geoprocessing menu item
* Select ArcToolbox
* Select Spatial Statistics Tools
* Select Analyzing Patterns
* Double click Spatial Autocorrelation (Moran’s I)
* For the Input Feature Class, add the shapefile (e.g., ct\_04)
* For the Input Field, select the desired variable for analysis (i.e., interval-ratio variables)
* Check Generate Report option box
* Select the Distance Method (e.g., Zone of Indifference, Contiguity\_Edges\_Corner)
* For Standardization, select Row
* Click OK
  + Output describes positive spatial autocorrelation only.

Method 2: GeoDa

* Click on Input File
* Select ESRI File Geodatabase
* Select geodatabase (e.g., lab.gdb)
* Click Select Folder
* Select layer (e.g., ct\_04)
* Open Weights Manager to begin creating weight file
* Click on Create
* Select the ID variable (e.g., GEOID)
* Decide on using Contiguity Weighting or Distance Weighting
* Contiguity Weight tab
  + Select Contiguity Weight (e.g., Queen contiguity)
  + Select Order of Contiguity (e.g., 1)
* Click Create
* Select where to save the file (e.g., the file geodatabase lab.gdb)
* Enter filename for .gal file (e.g., ct\_04\_Moran\_queen)
* Click Histogram to view the distribution
  + Should resemble Normal distribution for irregular polygons (e.g., census tracts)
* Click Connectivity Map for
* Click Connectivity Graph for
* Select Space menu
* Select Univariate Moran’s I
* Select the variable
* For Weights, select the weight file
* Click OK
* Graph is produced
  + Slope of line is the Moran’s I value.
  + Points in the lower left and upper right quadrants indicate positive spatial autocorrelation.
  + Points in the upper left and lower right quadrants indicate negative spatial autocorrelation.
* Evaluate spatial outliers as necessary
* Run Monte Carlo simulation
  + Right click on graph
  + Select Randomization
  + Select permutation
  + Resulting graph displays the pseudo p-value and z-value

Lecture Notes

Difference between Global and Local Spatial Autocorrelation

* Local disaggregates the Global statistic.
* Local has multi-valued statistics that can take on different values at different locations.
* Global statistics cannot be mapped; typically communicated in tables.
* Local is used to identify anomalies to theory.

Moran Scatter Plots

* Moran’s I can be thought of as a plot of X and lag-X (i.e., variable and spatial lag of the variable).
* An adjustment needs to be made for rate-based data (e.g., number of crimes per 1,000 population, number of infant deaths per 1,000 births, etc.)
  + Particularly if the rate denominator varies greatly.
  + Called the EB adjustment (Empirical Bayes Standardization)

Local Indicator of Spatial Association (LISA)

* Also called Cluster Analysis or Outlier Analysis
* Identifies which local values are statistically significant
  + Can reject null hypothesis that there is no spatial autocorrelation.

Lab Procedure

General Comments

* Dr. Sandoval recommends producing LISA maps in GeoDa
  + Calculations can be replicated manually.
* Use ArcMap to create more professional appearing map for presentation and publication.

Method 1: GeoDa

* Prepare for analysis
  + For input file, select shapefile from the file geodatabase (e.g., ct\_04)
  + Select Tools menu item
  + Select Weights Manager
  + Click Load
  + Select the weights file (e.g., ct\_04queen.gal)
  + Click Open
  + Click Histogram to view histogram
  + Close the window
* Create thematic map
  + Select the Maps menu item
  + Select Standard Deviation Map
  + Select variable (e.g., pblk)
  + Click OK
* Create spatial lag variable
  + Select Table menu item
  + Select Add Variable
  + Enter the name of the variable (e.g., slag\_pblk)
  + Select variable attributes
  + Click Add
  + Open the Attribute Table
    - Verify that the spatial lag variable was created
  + Select Table menu item
  + Select Calculator
  + Select Spatial Lab tab
  + Select the weight file (e.g., ct\_04queen)
  + Select the newly created spatial lag variable under Add Variable
  + Select the original variable (e.g., pblk)
    - Equation field should populate as “slag\_pblk = ct\_04queen \* pblk”
  + Click the use row standardized weights option
  + Click Apply
  + Open the Attribute Table
    - Verify that the calculation was successful
* Create scatter plot of spatial lag variable against the variable for Global Moran’s I
  + Select the Explore menu item
  + Select Scatter Plot
  + Select variable for Independent Variable X (e.g., pblk)
  + Select variable for Depended Variable Y (e.g., slag\_pblk)
  + Click OK
    - Scatter plot is created with best fit line (e.g., regression line)
    - Slope of the best fit line is the Moran’s I
* Calculate univariate Local Indicator of Spatial Association (LISA)
  + Select the Space menu item
  + Select Univariate Local Moran’s I
  + Select the variable (e.g., pblk)
  + Select the Weights file (e.g., ct\_04queen)
  + Click OK
  + Select the windows to open
    - Significance Map
    - Cluster Map
    - Moran Scatter Plot
  + Click OK
* Evaluate the degree to which two variables are correlated with each other globally
  + Select the Space menu item
  + Select Bivariate Moran’s I
  + Select the first variable (e.g., pblk)
  + Select the second variable (e.g., edtot)
  + Select the Weights file (e.g., ct\_04queen)
  + Click OK
  + Obtain significance levels
    - Right click on a window
    - Select Randomization
    - Select number of permutations (e.g., 999 permutations)
    - Click Run to re-run the permutations
* Evaluate the degree to which two variable correlate with one another locally
  + Select the Space menu item
  + Select Bivariate Local Moran’s I
  + Select the first variable (e.g., pblk)
  + Select the second variable (e.g., edtot)
  + Select the Weights file (e.g., ct\_04queen)
  + Click OK
  + Select the windows to open
    - Significance Map
    - Cluster Map
    - Moran Scatter Plot
  + Click OK
  + Obtain significance levels
    - Right click on a window
    - Select Randomization
    - Select number of permutations (e.g., 999 permutations)
    - Click Run to re-run the permutations
* To copy maps
  + Right click on window
  + Select Copy Image to Clipboard
* Export results (e.g., LISA) to process in ArcMap (for publication)
  + Right click on any window
  + Select Save Results
  + Select results to save
  + Enter names for the new variables to add to the attribute table
  + Click OK
  + Select the File menu item
  + Select Save As
  + For file path, select ESRI shapefile
  + Select the location to save the shapefile
  + Enter the name for the shapefile (e.g., geoda\_stl.shp)
  + Click Save
  + Click OK
  + Change field names if necessary
    - Click OK
  + Click OK

Method 2: ArcMap

* Add shapefile as map layer (e.g., ct\_04)
* Select Geoprocessing menu item
* Select ArcToolbox
* Expand Spatial Statistics Tools option
* Expand Mapping Clusters option
* Double click Cluster and Outlier Analysis (Anselin Local Moran’s I)
* For Input Feature Class, add the shapefile (e.g., ct\_04)
* For Input Field, select the variable (e.g., pblk)
* For Output Feature Class, select the file geodatabase (e.g., lab.gdb)
* Enter name for the new shapefile (e.g., lisa\_pblk)
  + Click Save
* For Conceptualization of Spatial Relationships, select desired contiguity (e.g., contiguity\_edges\_corners)
* For Standardization, select Row
* Click OK
  + LISA map added as a new layer
* Export the LISA map layer as a new shapefile
  + Right click on layer
  + Select Data
  + Select Export Data
  + For Output Feature Class, select the subfolder in the file geodatabase (e.g., lab/lisa)
  + Enter name for the new shapefile (e.g., stl\_lisa\_pblk)
  + Click Save