Introduction to Spatial Regression Analysis

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Objectives

The goal of this five-day course is to provide an overview of applied spatial regression analysis (spatial econometrics) that will enable participants to effectively incorporate these tools into their own empirical research. The course will introduce the broader field of spatial data analysis and the range of issues that generally must be dealt with when analyzing georeferenced data. Census-type data are among the most commonly encountered data that conform to this description, although the course acknowledges the wider range of data appropriate for spatial regression analysis.

Course Materials and Organization

The course will convene each day from 9:00 a.m. until approximately 4:30 p.m., except for the last day (Friday), when the course will likely wind down earlier to enable participants who must meet Friday evening flights to do so. The course is organized into a format that includes morning lectures (theoretical and conceptual underpinnings) and afternoon computing lab sessions (hands-on applications). We will attempt to set aside the last half hour or more of each day for group discussion of the topics introduced that day. Course materials are organized such that the readings supplement and provide greater detail on the topics covered in the classroom. Many more topics are introduced in the course lectures (assisted by PowerPoint) than can reasonably be absorbed in five intensive days, so the readings provide a point of return for review and deeper understanding of the topics covered, as well as a source of references for further reading. The lab exercises are guided by written, step-by-step tutorial instructions so that they can be repeated (and more fully absorbed) at a later time. All recommended readings and lab exercises are available on-line.
OUTLINE OF COURSE

Day 1 Morning:

1. Welcome and introductions
2. Review of objectives and overview of week
3. Goal and overview of the day
4. Motivational example
5. Understanding spatial data
   a. Overview of spatial data and spatial data analysis
   b. Spatial analysis vs. spatial data analysis
   c. Classes of problems in spatial data analysis
   d. Spatial vs. non-spatial data analysis
5. Why spatial is special
   a. Characteristics of spatial data
   b. Problems caused by spatial data
6. Review OLS assumptions
   a. Assumptions of the classical linear regression model
   b. Consequences of violation of the assumptions
7. Visualizing spatial data
8. Orientation to afternoon lab: Introduction to shapefiles (attribute data and digital map married up)

Day 1 Afternoon:

1. Constructing/finding a shapefile
2. Introduction to “our” shapefile; your task: Begin thinking now about hypotheses, models, and analyses
3. Simple mapping operations using ArcGIS
4. Reading a shapefile into GeoDa
5. Simple mapping operations using GeoDa

Day 1 Readings:

Day 2 Morning:

1. Q&A from readings or 1st day lecture or lab
2. Goal for the day: ESDA & spatial autocorrelation
3. Data exploration:
   a. Distribution aspects of dependent variable
   b. QQ Plots
   c. Linearity between dependent variable and independent variables
   d. Variable transformations
4. Global spatial autocorrelation & weights matrices
   a. What it is
   b. How it arises; Spatial processes
      i. Spatial heterogeneity
      ii. Spatial dependence
   c. Consequences of spatial autocorrelation
   d. How to measure it
      i. Weights Matrices
      ii. Global measures of spatial autocorrelation
         a. Global Moran statistic
         b. Global Geary statistic
         d. Problems with global measures
5. Local measures of spatial autocorrelation
   a. Local Moran
   b. Moran scatterplot
   c. LISA mapping
7. Orientation to afternoon lab: ESDA and spatial autocorrelation with GeoDa

Day 2 Afternoon:

1. Introduction to ESDA
2. ESDA with GeoDa
3. Creating and comparing weights matrices
4. Global spatial autocorrelation in GeoDa
5. Local spatial autocorrelation in GeoDa

Day 2 Readings:


**Day 3 Morning:**

1. Q&A from readings or 2nd day lecture, lab or readings
2. Goal for the day: understanding spatial regression
3. Spatial processes
   a. Spatial heterogeneity
      i. Define
      ii. Causes of
      iii. Problems arising from
      iv. Analogue to time-series analysis
         a. Corrections for
      v. GWR preview
   b. Spatial dependence
      i. Define
      ii. Causes of
         a. True contagion vs. false contagion
      iii. Expressions of
         a. Lagged dependent variable
         b. Unresolved heterogeneity; error lag
      iv. Corrections for
         a. Spatial lag model
         b. Spatial error model
         c. What these models mean/imply
         d. Relationship between the two models
         e. Higher order models
4. Common modeling strategy
   a. Specify and estimate OLS model
   b. Analyze the regression diagnostics
   c. Specify spatial model
   d. MLE fundamentals
5. Understanding the regression diagnostics provided by GeoDa
   a. Information criteria statistics
   b. Normality of errors
   c. Heteroskedasticity
   d. Lagrange multiplier statistics
6. Orientation to afternoon lab: OLS & spatial regression modeling with Geoda

**Day 3 Afternoon:**

1. OLS regression in GeoDa
2. GeoDa diagnostics and implications of these
3. Spatial regression models in GeoDa
4. Possible corrections for heterogeneity

Day 3 Readings:


Day 4 Morning:

1. Q&A from readings or 3rd day lecture, lab or readings
2. Goal for the day: understanding GWR
3. Introduction to GWR
   a. Theory and concept
   b. Local multivariate methods for spatial data analysis
      i. Spatial expansion model
      ii. Spatial adaptive filtering
      iii. Multilevel modeling
      iv. Random coefficient models
   c. GWR approach
   d GWR software
4. GWR analytical steps
5. What it means
   a. Spatial regimes
   b. Clues to interaction effects
   c. Clues to public policy messages in GWR maps
6. Cautions with GWR
7. Putting it all together: Example of a concrete spatial data analysis
8. Orientation to afternoon lab: GWR

Day 4 Afternoon:

1. GWR hands on

Day 4 Readings:

**Day 5 Morning:**

1. Q&A from readings or 4th day lecture, lab or readings
2. Goal for the day: Wrapping things up & introduction to spatial data analysis in R
3. Spatial data analysis in R
   a. Why R?
   b. Representing spatial data in R
   c. Visualizing spatial data in R
   d. Accessing spatial data in R
   e. Analyzing spatial data in R
4. Other software
5. Textbook resources for spatial data analysis
6. Useful websites and listserver
7. Orientation to afternoon: No lab, per se

**Day 5 Afternoon:**

1. Last chance to ask software questions
2. Hands on with R
3. Possible brief student presentations

**Day 5 Readings:**