SYLLABUS FOR

SOCIOLOGY 977
Seminar in Human Ecology:
SPATIAL DATA ANALYSIS FOR SOCIAL SCIENTISTS

Fall Semester, 2003
2:00 – 5:00 p.m., Wednesday
Room 10, Agriculture Hall
(Office hours: Thursday & Friday at
3:00 to 4:00 and by appointment)

Instructor: Paul R. Voss
Office: 316b Agriculture Hall
Phone: 262-9526
Fax: 262-6022
E-mail: voss@ssc.wisc.edu

"Sociologists study a wide variety of social, political, and economic phenomena. Many of these phenomena – for example, urbanization, political mobilization, economic development, diffusion of innovations – take place in and are distributed across geographical space. It is reasonable, therefore, to argue that sociologists are interested, indeed have long been interested, in social phenomena distributed in geographical space. Yet, in the main, our theoretical frameworks and data-analytic capabilities do not include the geography of social phenomena. As a result, the geographical characteristics of social phenomena are overlooked, especially when data analyses are performed. Thus there is a large lacuna in our theoretical frameworks and methodological apparatus."

Patrick Doreian
"Estimating linear models with spatially distributed data" (1981:359)

"...[U]ntil relatively recently, sociologists studying stratification in the United States neglected and (to some degree) resisted consideration of space. Insofar as stratification is at the theoretical core of sociology, this fact ensured that the discipline itself would remain largely aspatial."

Linda Lobao & Rogelio Saenz
"Spatial inequality and diversity as an emerging research area" (2002:497)

"...[W]hile epidemiology and demography possess a rich methodology, both disciplines are largely lacking a spatial perspective."

Michael Tiefelsdorf
Modelling Spatial Processes (Springer, 2000:151)

"Not surprisingly, most students find the study of statistics hard, and the study of spatial statistics very, very hard!"

Daniel A. Griffith and Carl G. Amrhein
Multivariate Statistical Analysis for Geographers (Prentice Hall, 1997:275)

This seminar has the goal of filling (portions of) the "lacuna" described by Doreian and echoed by

Lobao and Saenz. En route to that goal, we will attempt to disavow the claims both by Tiefelsdorf and by Griffith and Amrhein. Over the course of the semester, we will examine the characteristics of spatial lattice data (i.e., quantitative observations associated with fixed areas on a map) and will focus on methods of exploring and modeling such data. We will examine such issues as: the role of spatial regression modeling as part of general multivariate data analysis, the special difficulties that spatial data may create for regression approaches, the tools available for exploratory analyses of spatially referenced data; and the variety of models and approaches for undertaking multivariate regression in the presence of spatial heterogeneity and/or spatial dependence. The seminar, quite consciously, focuses on methods of analyzing and modeling variables measured over an irregular configuration of areal units. (It is not a coincidence that this may sound a lot like "census data".) Consequently, other important classes of spatially-referenced data, for example point patterns and continuous fields (and multivariate methods specific to them) will be largely ignored. Other courses on campus, such as Statistics 575, cover these materials very well. It should be emphasized that this is not a seminar in spatial statistics, *per se*, although we will draw heavily from this extensive body of evolving literature. Nor is this a seminar about geographic information systems/science (GIS), *per se*, although, again, the use of GIS tools and software in the course of spatial data analysis is included as an important part of the seminar.

Some prior experience with census Summary (Tape) Files and with GIS software is useful, but neither is a prerequisite. Students who do not have any experience with ESRI's suite of GIS software packages are encouraged to gain some facility with these during the course of this semester. We will also emphasize the utility of Luc Anselin's GeoDa™ exploratory spatial data analysis software and TerraSeer's SpaceStat™ regression software. Students familiar with other GIS and statistical software may use these tools – indeed will be encouraged to share their skills with the class.

What *is* an absolute prerequisite is a course in multivariate statistics and some experience with advanced regression analysis. It also is important that you have some familiarity with matrix notation and matrix algebra. (One very accessible introduction to the latter is Krishnan Namboodiri's *Matrix Algebra: An Introduction*, No. 38 in Sage Publication's Quantitative Applications in the Social Sciences.) If you feel you may not have a sufficient grounding in statistics, please see the instructor before considering yourself registered for this course.

The course is organized around a set of readings selected for the course and PowerPoint™ slides prepared for each class. Readings not indicated as **Discuss** or **Read**, are helpful but optional.

Class Electronic List. I will use electronic mail to communicate on various topics with the students in this class. Also, students are encouraged to raise and send questions and reflections to me about any of the topics covered in the lectures, PowerPoint™ slides, readings or exercises. I generally will respond to the questions by sending the answers to all students who are in the course. If you send me an e-mail message and do not want your question, and my answer, sent to all students in the class, please indicate so by typing APRIVATE@ at the beginning of the message. I check my electronic mail several times daily. The best way to communicate with me outside the classroom is through e-mail. My e-mail address is shown at the top of this syllabus.

Homework Assignments. There will be five assignments for you to complete outside of class and hand in, as indicated in the syllabus. Students may work together – for example, to help one

another with computer or GIS issues and discuss the materials that constitute the exercise. However, each student is required to prepare and submit summaries (including any computer work) on their own. If you received significant assistance from anyone you are expected to give credit for that in your write-up. You are encouraged to find a data set early in the semester (hopefully a data set that is interesting to you and may be used for your term paper) and use these data for Assignments 2-5.

These assignments have been adapted from assignments used by Luc Anselin in his Spatial Econometrics course at the University of Illinois. They are used with his kind permission.

The assignments will be graded on a scale from 0 to 10. Scores of 7 and 8 are given when the assignment is essentially done completely and correctly. Scores of 9 and 10 are reserved for complete and correct homework where extra initiative or innovation clearly sets the completed work above the simple, perfunctory and satisfactory completion of the assignment. Scores on homework assignments turned in late will be reduced by one point for each day they are late. A grade of zero is assigned to homework not turned in. Homework assignments with scores lower than 4 may be re-done within one week of the original due date with a penalty of two points on the second grade.

Lab Sessions. There also will be several lab sessions (in the Social Science Microcomputing Laboratory, 3218 Social Science) early in the semester. These lab sessions will provide introductions to ArcView, ArcGIS, SpaceStat and GeoDa for those who need such overviews. Attendance is encouraged, but optional.

Term Paper. A final term paper and in-class presentation is required. I am open to the idea of "group projects" for the final paper and presentation, provided there is no freeriding going on. I will ask that for a joint or group term paper you agree and submit to the instructor a written assessment of who did which work, and what proportion of total effort should be assigned to each participant. The topic of your term paper must be approved by the instructor no later than Friday, October 3rd. You are strongly encouraged to use data that is relevant to your own research.

Final Grade. The grade for this seminar will be determined as follows:

Participation in discussions	15%
Performance on assignments	15%
Written term paper	50%
Presentation of term paper	20%

Course Outline and Readings

Weeks 1 & 2. Introduction and Motivation. The nature of spatial data, spatial vs. non-spatial analysis, classes of problems in spatial data analysis, goals of spatial data analysis, spatial vs. non-spatial data analysis, types of spatial phenomena, types of spatial relationships, methods of spatial data analysis, spatial econometrics, spatial effects, spatial heterogeneity and spatial dependence, practical problems in spatial data analysis, general concepts in spatial data analysis, consequences of ignoring spatial dependence, visualizing spatial data, introduction to ArcView and ArcGIS.

Weeks 1&2 Lab Exercises: "Visualizing Spatial Data" (ArcView)
Assignment 1 (handed out 9/3; due 9/24)

> *"Until relatively recently, the complexities of spatial data were often ignored and spatial data were analysed with techniques derived for aspatial data, a classic case of this being regression analysis."*
>
> *Fotheringham, Brunsdon and Charlton*
> *Quantitative Geography: Perspectives on Spatial Data Analysis (Sage Publications Ltd, 2000:6)*

> *"[O]ur research illustrates the importance of spatial mechanisms in modeling social processes. The GGM [Galle, Gove and McPherson] analysis is only one of many examples of studies which use geographically defined areas without due consideration to interactions between units. The contrast between the GGM estimates and our spatial autocorrelation estimates suggests that a wide range of research findings should be reexamined to consider the effects of spatial processes."*
>
> *Colin Loftin and Sally K. Ward*
> *"A spatial autocorrelation model of the effects of population density on fertility" (1983:127)*

Readings, Weeks 1 & 2:

Discuss September 10: Loftin, Colin and Sally K. Ward. 1983. "A Spatial Autocorrelation Model of the Effects of Population Density on Fertility." *American Sociological Review*, 48(February):121-128.

Read: Anselin, Luc. 1989. "What is Special About Spatial Data? Alternative Perspectives on Spatial Data Analysis." *NCGIA Technical Paper 89-4*.

Read: Anselin, Luc. 1999. "The Future of Spatial Analysis in the Social Sciences." *Geographic Information Sciences* 5(2):67-76.

Read: Goodchild, Michael F., Luc Anselin, Richard P. Applebaum, and Barbara Herr Harthorn. 2000. "Toward Spatially Integrated Social Science." *International Regional Science Review* 23:139-159.

Anselin, Luc. 1988. *Spatial Econometrics: Methods and Models*. (Dordrecht: Kluwer Academic Publishers). [pp. 2-15.]

Bailey and Gatrell. 1995. *Interactive Spatial Data Analysis* (Edinburgh Gate, Harlow: Longman Ltd.). [pp. 3-40.]

Fotheringham, A. Stewart, Chris Brunsdon, and Martin Charlton. 2000. "Establishing Boundaries" (Chapter 1) and "Spatial Data" (Chapter 2) in *Quantitative Geography: Perspectives on Spatial Data Analysis* (London: Sage Publications).

Griffith, Daniel. 1996. "Introduction: The Need for Spatial Statistics." Pp. 1-15 in Sandra Lach Arlinghaus and Daniel A. Griffith (editors), *Practical Handbook of Spatial Statistics* (Boca Raton: CRC Press, 1996).
Griffith, Daniel A. and Carl G Amrhein. 1991. "Descriptive Statistics" (Part I) and "The Foundations of Inferential Statistics" (Part II) in *Statistical Analysis for Geographers* (Upper Saddle River, NJ: Prentice Hall).
Griffith, Daniel A. and Carl G Amrhein. 1997. "Elementary Statistics Background" (Chapter 1) and "Information Content in Geo-Referenced Data" (Chapter 2) in *Multivariate Statistical Analysis for Geographers* (Upper Saddle River, NJ: Prentice Hall).
Haining, Robert. 1990. "Issues in Analyzing Spatial Data." Chapter 2 in *Spatial Data Analysis in the Social and Environmental Sciences* (Cambridge, England: Cambridge University Press).
O'Sullivan, David, and David Unwin. 2003. "The Pitfalls and Potential of Spatial Data." Chapter 2 in *Geographic Information Analysis* (Hoboken, NJ: John Wiley & Sons).
Wrigley, Neil, Tim Holt, David Steel, and Mark Tranmer. 1996. "Analysing, Modeling, and Resolving the Ecological Fallacy." Pp. 23-40 in Paul Longley and Michael Batty (editors), *Spatial Analysis: Modelling in a GIS Environment* (Cambridge, England: GeoInformation Intenational).

Week 3. Computers and Spatial Data Analysis. Computer mapping, geographic information systems (GIS), GIS and spatial analysis, remote sensing, data integration, exploratory spatial data analysis (ESDA), spatial weights matrix, introduction to GeoDa, introduction to SpaceStat.

Week 3 Lab Exercise: Introduction to GeoDa™

"Integration of spatial statistical analysis and geographic information systems (GIS) is an important next step in the development of spatial analysis technocologies."

Daniel G. Brown
"Spatial statistics and GIS applied to internal migration in Rwanda, Central Africa" (1996:149)

"Given that it is not necessary to undertake spatial modelling within the framework of a GIS, and given that attempts to merge the two have sometimes resulted in a step backwards, do we really need to be concerned about integrating the two? And if spatial models are to be integrated within a GIS, what aspects of spatial modelling do we expect to benefit from the integration? ... I would argue that it is not ***necessary*** *to use to use a GIS to undertake spatial modelling and integrating the two will not necessarily lead to any greater insights into the problem at hand. However,* ***for certain aspects of the modelling procedure****, integration will have a reasonably high probability of producing insights that would otherwise be missed if the spatial models were not integrated within the GIS."*

A. Stewart Fotheringham
"GIS-based spatial modelling: a step forwards or a step backwards?" (2000:23)

Readings, Week 3:

Discuss September 17: Wheeler, Christopher, H. 2001 "A Note on the Spatial Correlation Structure of County-Level Growth in the U.S." *Journal of Regional Science* 41(3):433-449.
Read: Anselin, Luc, Ibnu Syabri, Oleg Smirnov and Yanqui Ren. "Visualizing Spatial

Autocorrelation with Dynamically Linked Windows." Unpublished manuscript.

Read: Anselin, Luc. 2000. "Computing Environments for Spatial Data Analysis." *Journal of Geographical Systems* 2:201-220.

Read: Maguire, D.J. & J. Dangermond. 1991. "The Functionality of GIS." Pp. 319-335 in David J. Maguire, Michael F. Goodchild, and David W. Rhind (eds) *Geographical Information Systems: Principles and Applications*. (Essex: Longman Scientific & Technical).

Read: Entwisle, Barbara, Ronald R. Rindfuss, Stephen J. Walsh, Tom P. Evans, and Sara R. Curran. 1997. "Geographic Information Systems, Spatial Network Analysis, and Contraceptive Choice." *Demography* 34(2):171-187.

Bailey and Gatrell. 1995. *Interactive Spatial Data Analysis* (Edinburgh Gate, Harlow: Longman Ltd.). [pp. 48-62.]

Entwisle, Barbara, Ronald R. Rindfuss, David K. Guilkey, Aphichat Chamratrithirong, Sara R. Curran, and Yothin Sawangdee." 1996. "Community and Contraceptive Choice in Rural Thailand: A Case Study of Nang Rong." *Demography* 33(1):1-11.

Fotheringham, A. Stewart, Chris Brunsdon, and Martin Charlton. 2000. "The Role of Geographical Information Systems" (Chapter 3) and "Exploring Spatial Data Visually" (Chapter 4) in *Quantitative Geography: Perspectives on Spatial Data Analysis* (London: Sage Publications).

Geoghegan, Jacqueline, Lowell Pritchard, Jr., Yelena Ogneva-Himmelberger, Rinku Roy Chowdhury, Steven Sanderson, and B. L. Turner II. 1998. "'Socializing the Pixel' and 'Pixelizing the Social' in Land-Use and Land-Cover Change." Pp. 51-69 in *People and Pixels*.

Rindfuss, Ronald R., and Paul C. Stern. 1998. "Linking Remote Sensing and Social Science: The Need and the Challenges." Pp. 1-27 in Diana Liverman, et al. (editors) *People and Pixels: Linking Remote Sensing and Social Science* (Washington, DC: National Academy Press).

Wood, Charles H., and David Skole. 1998. "Linking Satellite, Census, and Survey Data to Study Deforestation in the Brazilian Amazon." Pp. 70-93 in *People and Pixels*.

There are several monographs and edited volumes devoted almost exclusively to this topic. These tend to have more a GIS focus than a spatial data analysis focus, but they're worth exploring.

Chou, Yue-Hong. 1997. *Exploring Spatial Analysis in Geographic Information Systems* (Santa Fe: OnWord Press).

Fischer, Manfred M. and Peter Nijkamp (Eds.). 1993. *Geographic Information Systems, Spatial Modelling and Policy Evaluation* (Berlin: Springer-Verlag).

Fischer, Manfred, Henk J. Scholten, and David Unwin (Eds.). 1996. *Spatial Analytical Perspectives on GIS. GISDATA 4* (London: Taylor & Francis).

Fotheringham, Stewart and Peter Rogerson (Eds.). 1994. *Spatial Analysis and GIS* (London: Taylor & Francis).

Kemp, Zarine (Ed.). 1997. *Innovations in GIS 4* (London: Taylor & Francis).

Maguire, David J., Michael F. Goodchild, and David W. Rhind (eds). 1991. *Geographical Information Systems: Principles and Applications* (Essex: Longman Scientific & Technical).

O'Sullivan, David, and David Unwin. 2003. *Geographic Information Analysis* (Hoboken, NJ: John Wiley & Sons).

Scholten, Henk J. and John C. H. Stillwell (Eds.). 1990. *Geographical Information Systems for Urban and Regional Planning* (Dordrecht: Kluwer Academic Publishers).

Week 4. Spatial Autocorrelation. Defining spatial autocorrelation, spatial heterogeneity, spatial dependence, substantive spatial dependence vs. nuisance spatial dependence, true vs. apparent contagion, general cross-product statistics, join-count statistics, the need to impose structure, stationarity, intrinsic stationarity, contiguity and higher order contiguity, global autocorrelation statistics, Moran scatterplot.

Week 4 Lab Exercise: Computing Measures of Spatial Autocorrelation
Assignment 2 (handed out 9/24; due 10/1)

> *"Not all the problems of spatial data analysis revolve around spatial correlation but where this attribute is present, and it is probably more prevalent in studies at small spatial scales than large, the analyst must give serious thought to its representation. Here we should distinguish between those problem areas such as mapping and interpolation, where a good representation of spatial variation is the cornerstone of the work, from those problem areas where interest focuses on many attributes of the data and the analyst is more concerned to try to prevent spatial (auto) correlation from invalidating results or misleading the analyst or using it to reveal important data attributes. These last problems seem to be of particular importance in regression and correlation analysis in the social sciences."*
>
> *Robert Haining*
> *Spatial Data Analysis in the Social and Environmental Sciences (1990:386)*

Readings, Week 4:

Discuss September 24: Pacheco, Andrada I., and Timothy J. Tyrrell. 2002. "Testing Spatial Patterns and Growth Spillover Effects in Clusters of Cities." *Journal of Geographical Systems* 4:275-285. [Nice application of the Moran scatterplot.]

Read: Anselin, Luc. 1996. "The Moran Scatterplot as an ESDA Tool to Assess Local Instability in Spatial Association." Pp. 111-125 in Fischer, Manfred, Henk J. Scholten, and David Unwin (eds.) *Spatial Analytical Perspectives on GIS: GISDATA 4* (London: Taylor & Francis).

Read: Anselin, Luc, and Anil Bera. 1998. "Spatial Dependence in Linear Regression Models with an Introduction to Spatial Econometrics." Chapter 7 (pp. 237-289) in Aman Ullah and David Giles (eds.) *Handbook of Applied Economic Statistics* (New York: Marcel Dekker. [Read parts I and IIa-b.]

Bailey and Gatrell. 1995. *Interactive Spatial Data Analysis*. (Edinburgh Gate, Harlow: Longmann Ltd.). [pp. 247-333].

Cliff, Andrew D. and J. Keith Ord. 1973. *Spatial Autocorrelation* (London: Pion Limited).

Cliff, Andrew D. and J. Keith Ord. 1981. *Spatial Processes: Models and Applications* (London: Pion Limited).

Goodchild, Michael. 1986. *Spatial Autocorrelation*. CATMOG 47 (Norwich, England: Geo Books).

Griffith, Daniel A. 1987. *Spatial Autocorrelation: A Primer* (Washington, D.C.: Association of American Geographers).

Odland, John. 1987. *Spatial Autocorrelation*. Volume 9, Scientific Geography Series (Newbury Park: Sage).

Week 5. Model Specification. Issues in spatial dependence, specifying spatial covariance, spatial stochastic processes, SAR, CAR and SMA processes, spatial lag models, spatial error models, spatial spillovers, tests for spatial error and spatial lag dependence, issues in spatial heterogeneity, discrete heterogeneity, continuous heterogeneity.

Week 5 Lab Exercise: Introduction to SpaceStat™
Assignment 3 (handed out 10/1; due 10/15)

> *"A satisfactory spatial error model implied that it is unnecessary to posit distinctive effects of the lagged dependent variable. The observed spatial clustering in homicide rates is accounted for simply by the geographic patterning of measured and unmeasured independent variables.*
>
> *"The spatial lag model, in contrast, incorporates the spatial influence of unmeasured independent variables but also stipulates an additional effect of neighbors' homicide rates, i.e., the lagged dependent variable. This is the model most compatible with common notions of diffusion processes because it implies an influence of neighbors' homicide rates that is not simply an artifact of measured or unmeasured independent variables. Rather, homicide events in one place actually increases the likelihood of homicides in nearby locales."*
>
> *Robert D. Baller, et al.*
> *"Structural covariates of U.S. county homicide rates: incorporating spatial effects" (2001:567)*

Readings, Week 5:

Discuss October 1: Baller, Robert D., Luc Anselin, Steven F. Messner, Glenn Deane, and Darnell F. Hawkins. 2001. "Structural Covariates of U.S. County Homicide Rates: Incorporating Spatial Effects." *Criminology* 39(3):561-590.

Read: Anselin, Luc, and Anil Bera. 1998. "Spatial Dependence in Linear Regression Models with an Introduction to Spatial Econometrics." Chapter 7 (pp. 237-289) in Aman Ullah and David Giles (eds.) *Handbook of Applied Economic Statistics* (New York: Marcel Dekker. [Read parts IIc-IIIa.]

Read: Anselin, Luc. 2002. "Under the Hood: Issues in the Specification and Interpretation of Spatial Regression Models." *Agricultural Economics* 27(3):247-267.

Anselin, Luc. 2003. "Spatial Externalities, Spatial Multipliers, and Spatial Econometrics." *International Regional Science Review* (forthcoming).

Anselin, Luc. 1991. *The Performance of Tests for Spatial Dependence in a Linear Regression*. Technical Paper 91-13. National Center for Geographic Information & Analysis/NCGIA.

Baller, Robert D., and Kelly K. Richardson. 2002. "Social Integration, Imitation, and the Geographic Patterning of Suicide." *American Sociological Review* 67:873-888.

Weeks 6 & 7. Testing for Spatial Heterogeneity and Spatial Dependence. Testing for heteroskedasticity in a basic model, estimation of spatial regimes, the expansion method as a means of correcting for heteroskedasticity, spatial autocorrelation tests, tests against spatial AR/MA error, tests against spatial lag, specification robust tests, small sample properties.

Week 6 Lab Exercise: More SpaceStat™
Assignment 4 (handed out 10/15; due 10/29)

> *"[I]n general the behaviour of spatial phenomena is often the result of a mixture of both first order and second order effects. …[These concepts] are artifacts of the modeler and not reality. In practice, effects are confounded in observed data and the distinction between them is difficult and ultimately to some extent arbitrary. …If high values of a process are found in one region and low values among a set of adjacent sites in another region, then how do we know whether the underlying process is non-stationary (heterogeneous) or if these are local effects resulting from a homogeneous spatial dependence in the data?"*
>
> *Trevor C. Bailey & Anthony C. Gatrell*
> *Interactive Spatial Data Analysis*
> *(1995:34-35)*

Readings, Weeks 6 & 7:

Discuss October 8: Tolnay, Stewart E., Glenn Deane, and E.M. Beck. 1996. "Vicarious violence: Spatial Effects on Southern Lynchings, 1890-1919." *American Journal of Sociology* 102(3):788-815.

Read: De Graaff, Thomas, Raymond G.G.M. Florax, and Peter Nijkamp. 2001. "A General Misspecification Test for Sptaial Regression Models: Dependence, Heterogeneity, and Nonlinearity." *Journal of Regional Science* 41(2):255-276.

Read: Anselin, Luc, and Anil Bera. 1998. "Spatial Dependence in Linear Regression Models with an Introduction to Spatial Econometrics." Chapter 7 (pp. 237-289) in Aman Ullah and David Giles (eds.) *Handbook of Applied Economic Statistics* (New York: Marcel Dekker). [Read part IV.]

Anselin, Luc, and Raymond J.G.M. Florax. 1995. "Small Sample Properties of Tests for Spatial Dependence in Regression Models: Some Further Results." Chapter 2 (pp. 21-74) in Luc Anselin and Raymond J.G.M. Flowax (eds.) *New Directions in Spatial Econometrics* (Berlin: Springer.).

Anselin, Luc. 2001. "Rao's Score Test in Spatial Econometrics." *Journal of Statistical Planning and Inference* 97:113-139.

Anselin, Luc. 1988. *Spatial Econometrics: Methods and Models* (Dordrecht: Kluwer Academic Publishers). [pp. 65-73, 100-105.]

Anselin, Luc, and Harry H. Kelejian. 1997. "Testing for Spatial Error Autocorrelation in the Presence of Endogenous Regressors." *International Regional Science Review* 20:153-182.

Florax, Raymond J.G.M., Hendrik Folmer, and Sergio J. Rey. 2002. "Specification Searches in Spatial Econometrics: The Relevance of Hendry's Methodology." *WUSTL Economics Working Paper*.

Kelejian, Harry H., and Dennis P. Robinson. 1998. "A Suggested Test for Spatial Autocorrelation and/or Heteroskedasticity and Corresponding Monte Carlo Results." *Regional Science and Urban Economics* 28:389-417.

Weeks 8 & 9. Estimation. Maximum likelihood (ML) estimation, instrumental variables (IV) estimation, general method of moments (GMM) estimation, ML basic principles, ML estimation of spatial lag model, ML estimation of spatial error mode, spatial two stage least squares, GMM estimation of spatial error model, Bayesian estimation, MCMC, spatial filtering.

Assignment 5 (handed out 10/22; due 11/5)

> *"Cross-sectional spatial regression models are often formulated such that they permit interdependence between spatial units. This interdependence complicates the estimation of such models."*
>
> *Harry H. Kelejian & Ingmar R. Prucha*
> *"A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances"*
> *(1998:99)*

Readings, Weeks 8 & 9:

Discuss October 22: Getis, Arthur, and Daniel A. Griffith. 2002. "Comparative Spatial Filtering in Regression Analysis." *Geographical Analysis* 34(2):130-140.

Discuss October 29: Doreian, Patrick. 1981. "Estimating Linear Models with Spatially Distributed Data." Pp. 359-388 in Samuel Leinhardt (ed.) *Sociological Methodology, 1981* (San Francisco: Jossey-Bass).

Discuss October 29: Doreian, Patrick. 1980. "Linear Models with Spatially Distributed Data: Spatial Disturbances or Spatial Effects?" *Sociological Methods & Research* 9(1):29-60.

Read: Anselin, Luc, and Anil Bera. 1998. "Spatial Dependence in Linear Regression Models with an Introduction to Spatial Econometrics." Chapter 7 (pp. 237-289) in Aman Ullah and David Giles (eds.) *Handbook of Applied Economic Statistics* (New York: Marcel Dekker. [Read pp. 255-258.]

Anselin, Luc. 1988. *Spatial Econometrics: Methods and Models*. (Dordrecht: Kluwer Academic Publishers). [pp. 57-65.]

Bell, K. and N. Bockstael. 2000. "Applying the Generalized Moments Estimation Approach to Spatial Problems Involving Microlevel Data." *The Review of Economics and Statistics* 82:72-82.

Conley, T. 1999. "GMM Estimation with Cross-Sectional Dependence." *Journal of Econometrics* 92:1-45.

Kelejian, Harry H., and Ingmar R. Prucha. 1997. "Estimation of Spatial Regression Models with Autoregressive Errors by Two-Stage Least Squares Procedures: A Serious Problem." *International Regional Science Review* 20:103-111.

Kelejian, Harry H., and Ingmar R. Prucha. 1998. "A Generalized Spatial Two-Stage Least Squares Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances." *Journal of real Estate Finance and Economics* 17(1):99-121.

Kelejian, Harry H., and Ingmar R. Prucha. 1999. "A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model." *International Economic Review* 40:509-533.

Ord, J. Keith. 1975. "Estimation Methods for Models of Spatial Interaction." *Journal of the American Statistical Association* 70:120-126.

Week 10. Local Forms of Spatial Analysis. Geographically weighted regression, LISA (local indicators of spatial association), local Moran, Getis G_i and G_i* statistics,

> *"Imagine reading a book on the climate of the United States which contained only data averaged across the whole county, such as mean annual rainfall, mean annual number of hours of sunshine, and so forth. Many would feel rather short-changed with such a lack of detail."*
>
> *A Stewart Fotheringham, Chris Brunsdon & Martin Charlton*
> *Geographically Weighted Regression (2002:1)*

Readings Week 10:

Discuss November 5: Atkinson, Peter M., Sally E. German, David A. Sear, and Michael J. Clark. 2003. "Exploring the Relations between Riverbank Erosion and Geomorphological Controls Using Geographically Weighted Logistic Regression." *Geographical Analysis* 35(1):58-82.

Read: Anselin, Luc. 1995. "Local Indicators of Spatial Association – LISA." *Geographical Analysis* 27(2):93-115.

Read: Fotheringham, A. Stewart, and Chris Brunsdon. 1999. "Local forms of Spatial Analysis." *Geographical Analysis* 31(4):340-358.

Getis, Arthur, and J. Keith Ord. 1996. "Local Spatial Statistics: An Overview." Pp. 261-277 in Paul Longley and Michael Batty (eds.) *Spatial Analysis: Modelling in a GIS Environment* (GeoInformation International).

Fotheringham, A. Stewart, Chris Brunsdon & Martin Charlton. 2002. *Geographically Weighted Regression* (West Sussex: John wiley & Sons, Ltd.).

Leung, Yee, Chang-Lin Mei, and Wen-Xiu Zhang. 2003. "Statistical Test for Local Patterns of Spatial Association." *Environment and Planning A* 35:725-744.

Week 11. Advanced Topics. Space-time models, spatial seemingly unrelated regression (SUR), spatial probit models, methods for spatial interaction data, exploring spatial interaction data, modeling spatial interaction data, basic spatial interaction or gravity models, estimating parameters of gravity models, variations of the gravity model, location-allocation problems, network problems, spatial models of residential segregation.

> *Economic geography and regional economics have since their inception focused attention on the analysis of spatial patterns of human activities, in both the production and household field. … In recent decades however, the focus of interest has shifted towards the analysis of spatial movements, i.e. the processes or spatial flows emerging as a result of given spatial configurations.*
>
> *Peter Nijkamp and Aura Reggiani*
> *Interaction, Evolution and Chaos in Space* (Springer-Verlag, 1992:3)

Readings Week 11:

Discuss November 12: Borgoni, Riccardo, and Francesco C. Billari. 2003. "Bayesian Spatial

Analysis of Demographic Survey Data: An Application to Contraceptive Use at First Sexual Intercourse." *Demographic Research* 8(3):61-92.

Read: Pace, R. Kelley, Ronald Barry, John M. Clapp, and Mauricio Rodriquez. 1998. "Spatiotemporal Autoregressive Models of Neighborhood Effects." *Journal of Real Estate Finance and Economics* 17(1):15-33.

Anselin, Luc. 1988. *Spatial Econometrics: Methods and Models*. (Dordrecht: Kluwer Academic Publishers). "Models in Space and Time." (Chapter 10).

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Weeks 12 through 14: Student presentations