Projeto # 10
Land use and economic development in Brazil
Diana Weinhold, DESTIN/LSE, UK

The overarching theme of the project is the analysis of the relationships between land use (and hence environmental) change and economic development in Brazil. In many cases there may be trade-offs between environment and development, while in other cases the two objectives may be complementary. This project will employ and develop a variety of state-of-the-art methodological tools to examine and quantify these trade-offs and complementarities in several key areas of particular importance to Brazilian and international policy makers.

The first policy focus of the project will center on an analysis of the relationship between the expansion of soybean cropland, pasture for cattle and land clearing, and the impacts of soy cultivation on economic growth and income distribution. Soybean has become a major agricultural story in Brazil (for example see Vera-Diaz et.al. 2006), but has come under intense criticism from some national and international environmental groups for its role in increasing deforestation while only benefiting a few large landholders. However other studies (such as Brandao, Rezende and Costa Marqes 2005) have challenged this view. Using rigorous spatial and dynamic econometric analysis (see discussion below under methodology) we will combine annual data on soy and cattle production through 2004 with many other control and socioeconomic variables to address the question of the extent to which soy bean production is increasing clearing rates, and whether the soy crop is displacing, or simply substituting, for cattle pasture where it has advanced. In addition we intend to examine the impact of soybean production on economic growth, including local economic development indicators such as income distribution and the poverty rate.

The second line of research will examine the role of transport costs in the historical and contemporaneous economic development of Brazil, and in particular on land use choices. Again, it is widely argued that there are severe negative trade-offs between environmental protection and transportation costs, with improved roads leading to increased deforestation and land clearing (see, for example, Pfaff 1999). Other evidence, however, has suggested that well-placed roads may not have such a negative impact on the environment (see for example, Andersen et al 2002). However most previous work on this topic has only marginally employed spatial econometric methodology, instead for the most part treating each observational unit (be it census unit, municipio, or country) as an independent observation. In addition the primary focus of most studies has been on the environmental consequences with very little attention paid to the potential economic and welfare benefits. Our project will aim to provide some quantitative estimates of the trade-offs between transport costs, land clearing and economic growth when they do occur, and to better identify if and where those trade-offs may be minimal. Methodologically we intend to fully employ spatial and dynamic econometric techniques that treat each unit of observation as inherently spatially linked across many dimensions as well as through time, and thus be able to much better discern the spatially and dynamically distant impacts of policy interventions such as road improvements.

Methodology

The project will focus on topics in which the crucially important factor is the relationship between spatial location, heterogeneity (both in space and in other characteristics), and the outcomes of interest such as economic development and land. Methodologically a strength of this research will been to explicitly model the relationships as both dynamic and spatial in nature.

Most of the research undertaken on these issues to date has been limited by the nature of how data is collected; the units of analysis being politically determined countries, states or counties. While some researchers have brought the standard arsenal of spatial econometrics to bear on these issues, generally this involves controlling for a specific (often rather ad hoc) spatial dependence across a limited range (again, determined rather ad hocly) of the units of analysis that are present in the data set. Often it is less than that; simply controlling for some (also ad hoc) form of spatial dependence in the residuals.

However, Geographic Information Systems (GIS) analysis promises a radically new way to directly test hypotheses about spatial relationships. By allowing researchers to attach geo-referenced information to data points, very specific questions about particular patterns of spatial

evolution and spatial dependence can be directly addressed in a way that is much more computationally feasible than before.

Despite its promise, however, there is still a fair amount of methodological improvements to be made in the use of GIS analysis in the field of social research, and that will be a major component of the current project. Two areas where we hope to push forward the methdological frontier are in the parameterization (i.e. specification) of possible spatial relationships, and in the analysis of data that display both spatial and dynamic dependence.

In particular, the first problem involves the fact that given the practically infinite degrees of freedom a social researcher has in fashioning GIS spatial variables, if these methods are to be used in modelling social and economic behaviour, a very strong (spatially specific) theoretical foundation is required. If this is lacking, or the theory suggests a strong spatial effect but cannot be more specific about its nature, then a researcher could face quite a problem. You can test whether there is a spatial relationship of the specific nature you have hypothesized, but beyond the standard set of tests for spatial dependence (that suffer from being rather ad hoc and computationally limited) or (perhaps more successful) 'eyeball' tests, it is much more difficult (perhaps impossible) to ask whether there might be other spatial relationships that are equally or more important but being overlooked. While this problem may never be solved completely, the methodological approach that I developed for systematic model selection in the face of a large number of possible explanatory variables ("random reduction") and that was used for the quantitative analysis in our jointly authored CUP book (see Andersen et al 2002), could potentially be of use. In particular it should be straightforward to extend this approach to provide a relatively systematic way of searching across a number of alternative spatial configurations and minimize the possibility of missing large but initially hidden effects lurking around the data space.

Of course the usual caveats and safeguards against data mining would apply; these are all questions that would need much more formal investigation. Fortunately, another area of econometric research that I have ongoing at the moment focuses on the ability of using out-of-sample forecasting ability to evaluate competing models. The approach is well understood and commonly used in the time series literature (Mariano and Diebold 1995), but the intuition doesn't necessarily carry over automatically to more cross-section (and spatial) models (Granger and Huang, 1997). A component of my previous and current research involves determining under what conditions these out-of-sample forecasting tests can be validly used for panel and cross section model evaluation (for example, see Weinhold and Reis 2001). Thus, given a menu of possibly important GIS-generated spatial variables (perhaps distilled from a random reduction procedure), it will be interesting to see to what extent out-of-sample forecasting (in space, perhaps) can be useful as a diagnostic tool.

Finally, while time series dependence in data is one of the most studied phenomena in econometrics, and spatial dependence (in the cross section) has also received a fair amount of attention, there has been less work on the complications that arise from dependence that is both spatial and dynamic. As many policy questions revolve around the impact of intervention X in time t on some spatially distance location Y in time t+k, getting a better understanding of how to jointly model spatial and time dependence will be an important component of the project. While future work may entail more theoretical contributions, for the immediate future a more practical approach may be taken, using monte carlo analysis to examine the performance of out-of-sample forecasting tests in evaluating competing models and the extent to which this technique can be useful for jointly dependent data.

Expected Outputs

The project will produce two empirical papers on the policy topics discussed above, namely the relationship between soy production, land use and economic growth and the spatial and dynamic land use impacts of transport costs. These studies should provide quantitative and qualitative estimates of the trade-offs between environmental costs and economic growth that should be helpful for policy makers. In addition we expect to produce one or two methodological papers focusing on the use of spatial GIS analysis for socio-economic modelling. These should provide guidance and develop new techniques for model specification and evaluation when data are jointly spatially and dynamically dependent.

Selected References

Andersen, Lykke E., Clive W. J. Granger, Eustaquio J. Reis, Diana Weinhold and Sven Wunder, The Dynamics of Deforestation and Economic Growth in the Brazilian Amazon, Cambridge University Press, Cambridge UK December 2002

Brandão, Antonio Salazar Pessoa and Gervásio Castro de Rezende, and Roberta Wanderley da Costa Marques "CRESCIMENTO AGRÍCOLA NO PERÍODO 1999-2004, EXPLOSÃO DA ÁREA PLANTADA COM SOJA E MEIO AMBIENTE NO BRASIL", IPEA Discussion Paper 1062, January 2005

Carvalho, G.O., A.C. Barros, P. Moutinho, and D. Nepstad. 2001. Letter to the Editor: Sensitive development could protect Amazonia instead of destroying it. *Nature.* 409:131.

Diebold, F.X. and R.S. Mariano, "Comparing Predictive Accuracy," *Journal of Business and Economic Statistics*, v. 13, pp. 253-264, 1995

Granger, C.W.J and L. Huang, "Evaluation of panel data models: some suggestions from time series" unpublished manuscript, U.C.-San Diego February 1997

Pfaff, Alexander S. P., "What Drives Deforestation in the Brazilian Amazon? Evidence from Satellite and Socioeconomic Data" *Journal of Environmental Economics and Management* vol. 37 pp. 26-43, 1999

Vera-Diaz, Maria del Carmen, and Robert K. Kaufmann, Daniel C. Nepstad, and Peter Schlesinger. "An interdisciplinary model of soybean yield in the Amazon Basin: the climatic, edaphic,and economic determinants", Manuscript Draft 2006

Weinhold, Diana and Eustaquio J. Reis, "Model evaluation and causality testing in short panels: The case of infrastructure provision and population growth in the Brazilian Amazon" *Journal of Regional Science*, November 2001, vol. 41, no. 4, pp. 639-657(19).