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Research on Agent-Based Interactions

My research focuses on spatially disaggregate, economic models of land use conversion and household location patterns. My main research interest with respect to agent-based interactions has been on the empirical identification of interactions among landowners who convert their land to development and the role of these spillovers in generating "sprawl" patterns of development. A secondary research focus has been on the development of a cellular automaton that simulates the net effect of negative endogenous interactions among developed land parcels and the positive, attracting effects of a city center and built infrastructure (e.g. roads). My current research interests include the development of an agent-based model of urbanization in which environmental amenities (such as open space and water quality) are endogenous to household location. In what follows, I elaborate on each of these research areas.

Identification of Interaction Effects Among Agents

Manski (1993, 1995), Brock and Durlauf (2001), and Moffitt (1998) have given serious attention to the challenges involved in identifying interaction effects among agents within a regression context. This work discusses three major identification problems that arise in testing for the presence of interactions among agents: the simultaneity problem, the endogenous group formation problem, and the correlated unobservables problem. My research on identifying the spillover effects among developed land parcels has focused on the problem of unobserved spatial correlation in a discrete choice, duration modeling framework. An identification problem arises here because omitted spatial variation leads to correlation between the error and interaction terms, which biases the interaction estimate upwards if uncontrolled.[1] As a result, a positive interaction effect may be estimated even in the absence of such any interaction. Solving this problem for cross-sectional models and discrete choice models is difficult. Solutions that have been proposed in the literature include assigning an upper bound to the interaction effect, using instrumental variables or related approach called a partial population identifier, and conditioning out the unobserved component using an analog of a fixed effects approach for discrete choice models. Irwin and Bockstael (2001a) use the strategy of bounding the interaction effect to identify negative interactions among developed parcels, which offers one explanation for sprawl development. In related research, Irwin and Bockstael (2001b) and Irwin (2001) use an instrumental variables and partial population identifier respectively to identify the effects of open space spillovers in a hedonic model of residential property values.

Cellular Automaton Model of Development

Irwin (1998) employs cellular automaton to explore the evolution of regional patterns of development with a negative interaction effect among developed parcels and offsetting positive spillovers from a city center and other built infrastructure, all of which decay over distance. Parcels are represented by cells arranged on a two-dimensional square lattice and each parcel

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[1] This same problem arises in the literature on own-state dependence over time, which seeks to separate "true" temporal state dependence (e.g. habitual effects) from "spurious" state dependence (Heckman, 1978, 1981).

takes on only one of two states, undeveloped and developed. The growth parameter and unit of time are defined such that one parcel is developed in each time period. Agents form expectations over the returns to converting by considering the location of the parcel relative to exogenous features and the amount of development that surrounds the parcel in the current period. Agents are assumed to be myopic in the sense that they do not attempt to forecast future changes in their neighboring land use patterns. Once converted, the expected costs from re-converting a parcel back to an undeveloped state are assumed always to exceed the returns of re-conversion, so that development is effectively irreversible. Multiple simulations are performed by altering the distance decay parameters that govern the relative strength of the negative and positive effects. The results demonstrate that varying degrees of clustering and fragmentation emerge, depending on the relative values of the neighborhood interaction and other parameters. In particular, they identify the minimum threshold value required for the negative interactions to generate a sprawl pattern of development.

Irwin and Bockstael (2001a) use a cellular automaton to predict patterns of land use change using estimated parameters from an empirical model of land use conversion to calculate the transition probabilities for yet undeveloped parcels. Because the development spillover is endogenous, these probabilities are then updated with each round of development.

Agent-Based Model of Urbanization with Endogenous Environmental Amenities

The development of this model is still in the very formative stages and is joint work with several others. Initially we are developing a simple model of household location within a region with a given distribution of employment, infrastructure, and environmental resources. Households are differentiated by income and preferences over access to employment and environmental quality. The system evolves with new population being added in each time period and the relocation of existing households, based on utility-maximizing behavior. Environmental quality, which is specified as water quality and surrounding open space, is endogenous and acts as an attractor. A primary goal of this modeling effort is to work with biological and physical modelers to develop an integrated and dynamic model of the human/biological/physical systems associated with Lake Erie. Extensions of this model will include making roads, employment, and public services endogenous to household location, so that the entire urban spatial structure of the region can be modeled in a dynamic framework. Ultimately this modeling effort will seek to explain the endogenous interactions between household location and environmental quality, redistribution of population from a city center to suburbs and exurbs, the formation of edge cities, and the fragmented pattern of exurban residential development within a region.

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