Introduction Continued: Scale and level, Processes to be modeled

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Scale definitions

- Temporal: time step and duration
- Spatial: resolution and extent (fine scale and broad or coarse scale)
- Human: agent and domain

Three related concepts

- Scale and/or level
- Exogenous and endogenous model components
- Conditional probabilities

Questions:

- Questions from last week's lecture or readings
- Questions for this week

Identifying and representing spatial, temporal, and behavioral complexity

Land-use modeling techniques and applications, Lecture 2

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From “questions” list:

What real-world spatial, temporal, and behavioral processes do you strive to represent?

and

What is the minimum level of complexity for the model?

Main questions to consider

- What spatial, temporal, and behavioral processes do we believe are important in the system we want to model?
- How much complexity do we need to build into our model to capture those processes?
- How little complexity can we get away with?

Complexity

- Many uses of this word in modeling
- Here, “complex” means
  - not simple
  - having many elements change within the model
  - operating at multiple levels or scales
- We will discuss:
  - sources of spatial, temporal, and behavioral complexity
  - what is determined within the model, and what information is external
  - what cross-scale feedbacks are present

Spatial Complexity: Spatial autocorrelation

- Example: one land use is more likely when it has another land use type as a neighbor, due to:
  - Technology adoption and other imitative behavior
  - Scale economies (synergies between activities)
  - Spatial competition (example: coffee shops)
  - Negative spatial spillovers/externalities
  - Ecological spillovers (edge effects)

More spatial complexity: Spatial dependence

- Example: two land uses share a similar spatial characteristics, such as
  - Soil type
  - Accessibility
  - Climate
  - Topography
  - Political zone
- Note this type of spatial dependence may motivate using data at different spatial scales in your model

More spatial complexity: Networks

- Physical:
  - transportation infrastructure
  - hydrology
- Social:
  - communication
  - social ties
  - trade and commerce

Spatial complexity: Implementation

- CA models: cell type is based on states of neighboring cells
- Multi-scale models capture top-down spatial interactions
- MAS models can explicitly incorporate all types of spatial interactions, especially networks
- Spatial econometrics models incorporate spatial autocorrelation and spatial dependence

Temporal complexity: Growth and decay

- Population growth and decline (animal and human)
- Soil degradation
- Carbon sequestration
- Erosion
- Social trends
- Financial investments

Temporal complexity: Temporal lags

- Growth and decay functions lead to temporal autocorrelation (this time period's state depends on last time period's)
- Modeling current state may require information on states in previous time periods
- For processes that also diffuse over space, it may require both spatial and temporal lags (example: species colonization)

Temporal complexity: Path dependence

- Different conditions at one time period can lead to very different outcomes over space and time
- This is an important source of uncertainty in modeling

Temporal complexity: forward-looking behavior

- Humans and other animals are forward-looking. Examples:
  - Food and seed storage
  - Crop rotation
  - Strategic behavior, such as pre-emptive land clearing
- Successful models must take this into account
- Therefore, models must build in expectations of the future and possible responses

Temporal complexity: fast vs. slow processes

- Some decisions are influenced by short-term processes (eg, weather, pest invasions)
- Others depend on longer-term processes (eg, climate change, soil degradation)
- May motivate representing multiple temporal scales in models

Temporal complexity: implementation

- Possible in modified CA models
- Statistical/econometric models with temporal autocorrelation
- Dynamic projection methods that account for feasible change trajectories
- Many dynamic simulation and optimization models we will see account for temporal dynamics to some extent: issues relate to modeling agent decision making

Behavioral Complexity

- Different types of actors
  - Public land managers
  - Farmers
  - Developers
  - Urban residents
- Multiple goals
- Heterogeneity within:
  - Expectations
  - Strategies
  - Motivations
- Interconnectivity of agents in social, economic, and ecological networks

Behavioral complexity: Implementation

- CA models have no behavioral representation
- Optimization models can embed behavior, given their assumptions
- Statistical models identify drivers based on assumptions about behavior; analysis of survey data can formalize assumptions
- ABM models can represent a wide rage of behavioral complexity

How many model elements are determined within the model?

- Issue here is the degree of endogeneity, or connectedness, of the components of the dynamic system
- The more endogeneity is present, the broader the scope of the model, and the larger the number of questions that can be asked and answered with the model
- The more endogeneity is present in a model, the more difficult it is to analyze and understand its workings

Cross-scale dynamics

- Higher-level processes often constrain lower-level processes
- Lower-level processes may feed back to influence higher-level processes

Example: roads, colonization, and deforestation

- National level policies (subsidized timber prices and/or roads) encourage road construction and deforestation
- National level policies (distribution of land for frontier settlement) encourage settlement along roads
- Rural ag. producers become more integrated with the market (new people, new techniques, new opportunities)
- Results may be greater sensitivity to financial factors such as ag prices, off-farm wages, credit, timber prices) (Angelsen and Kaimowitz)

Example: Residential location and employment

- Spatial structure at one level determined as residents locate within commuting distance of place of employment
- Spatial structure at another level determined as firm locates around other complementary firms (result is polycentric node)
- Spatial structure at higher level determined by relationship between polycentric nodes
- At a still higher level, spatial structure between cities is determined through migration (Anas et al.)

Example: Ag production and price feedbacks

- Spike in demand may cause ag extensification (production on previously marginal lands). Example: organic rice for Japanese consumption
- Increased supply at a local level feeds back to depress globally determined price (classic cobweb model)
- Note that integration of new markets may have the same effects (example: coffee production)

Cross-scale dynamics: implementation

- Inductive analysis of influence of drivers at different scales
- Cross-scale (multi-level statistical methods)
- Results from macro-scale distributed to micro-scale (top-down)
- In land-use change models, total quantity of change is often determined first, then distributed over space

Definitions:

- **Proximate causes** (Geist and Lambin)/sources (Angelsen and Kaimowitz): action by agents that leads to land-use change (specifically, deforestation)
- **Underlying driving forces/underlying causes**: factors influencing agent decision making at many levels

Definitions (economic)

- **General equilibrium**: model in which key prices and resource allocations are endogenous
- **Time preference/discounting**: Time preference refers to the weight that an agent gives to current consumption vs. future consumption. The discount rate is similar to an individual rate of interest.
- **Risk aversion**: Risk-averse agents prefer a sure payoff to a bet with an expectation of a higher payoff (explain)

Economic defs. Cont.

- **Externality:** A cost or benefit of a choice made by a given actor that accrues to someone else, where the decision-making does not account for this cost or benefit in his/her decision.
- **Market failure**: An economic outcome in which externalities occur at a level that does not balance marginal social costs against marginal social benefits

Economic defs, cont.

- **Perfect markets**: All goods can be traded at competitive market prices (no monopoly power)
- **Shadow prices**: The value to an agent of an additional (marginal) unit of some input resource (discuss this). In a competitive economy with perfect markets, will be the shadow price for some agent.

Economic defs, cont.

- **Land rent**: The market value of the current land use; the shadow price of land
- **Agricultural intensification**: Many defs; generally means cultivation methods to produce more from the same land resource
- **Agricultural extensification**: Expansion of production into previously unused (often marginal) lands.

Economic defs. Cont.

- **"Inelastic" demand**: Large changes in prices cause very little change in purchase behavior (classic example is prescription drugs)
- **Returns to scale (economic):** Average unit costs of production fall as the size of the firm increases. Geographically, this can mean it take up more space. It also may employ more people.

Economic defs., cont:

- **Monopolistic competition**: Firms offer specialized products that potentially substitute for other similar but specialized products (restaurants). Many models of spatial monopolistic competition (spatial market niche)
- **Vertical integration**: Supply chain (from raw materials to final product marketing/distribution) integrated within a single firm

Economic defs, cont.

- **Returns to scale (economic):** Average unit costs of production fall as the size of the firm increases. Geographically, this can mean it take up more space. It also may employ more people.
- **Economies of Scope:** Average costs of one or more products fall as the firm diversified production into other goods.
- **Economies of Agglomeration**: Economies of scale and/or scope between firms; knowledge and technology spillovers, sharing of a pool of qualified labor

Economic defs., cont.

- **Shadow value of time:** The value to an individual of sacrificing additional leisure/labor. Often assumed to be the wage rate (thus linked to income). Explain assumptions of labor/leisure model.
- You can gloss over these sections of the Anas article that you can gloss over are posted on the "news forum" on the website

Anas article reading guide

Notes for Anas article:

- Pay careful attention to Section 2. I found this section very interesting, especially with respect to the influence of transportation structure on urban form and location.

- Section 3 has more math, but most of it is well interpreted in words. Pay attention to the interpretation of equation 2; this is one of the most basic in urban location theory. You can comfortably gloss over the details of the mathematical models in this section and focus on conclusions and interpretation. The section alternates between empirical observation and potential theoretical explanations. The details of the later are not important for this class.

- Section 4 is mainly empirical and is quite interesting.

- Section 5 should be pretty easy to follow, given the definitions we went over in class.

- While I find section 6 interesting and some of you who are interested in urban policy might, it is not as important for this class.