Assignment #5: Exercises in Adding Model Structure

Purposes

Structural additions to existing models provide a challenging but supportive arena for developing skills in model conceptualization and formulation. Beginning with an existing model, one is relieved of the tasks of problem identification, initial conceptualization, and formulation. The model already runs, and presumably runs well. Time need not be spent in research or data-gathering. However, conceiving of new structure to address a question not addressed or not handled well by the existing model still involves most of the conceptual and formal skills of model building.

Furthermore, such exercises capture an often repeated part of the normal iterative process of model-building: one commonly starts with a basic model and extends it over and over with structural additions, heading toward a model complete enough to address the problems for which it was intended.

Read each of the following exercises. Pick one to do and hand in. As the above comments suggest, you would be well-advised to do both of them at some point, but for this exercise you only need to do one, the one you find the most interesting, the most challenging, the most instructive, or the easiest, depending on your priorities at this point.

Whatever formulation exercise you pick,

- Start simply.
- Try to have a running model at (almost) all times (add a little structure; simulate; add a little more structure; simulate; and so on).
- Strive initially for realistic structure that captures what people do.
- Do not hunt for "optimal" policy.
- Follow the initial formulation suggestions.
- Don't think about the "after thoughts" until you are essentially all done.

When you are through with the basic reformulation exercise, you may work with your revised model to try to improve the behavior of the system, but the real focus of this exercise is on formulation, not policy analysis.
(1) Adding a zoning structure to URBAN1.

Background

URBAN1 is the simple model used in the Understanding Model Behavior exercise and showing an urban life cycle of growth, stagnation, and decay. The mature city in the base run of that model shows high unemployment (a labor force/job ratio greater than 1) and abandoned housing structures (a households-to-housing ratio considerably less than 1).

The city may be made more economically healthy by a zoning policy that reserves more land for job-generating business structures. However, actors in the system would not know how much land to allocate to housing and business structures. They would have to learn over time as the history of city unfolds.

Problem

Add structure to URBAN1 representing a zoning policy that strives to respond to pressures from employment and housing conditions.

A good way to proceed would be to formulate a level for land zoned for business and obtain the desired fractional change in that level from perceptions of the laborforce-to-job and households-to-housing ratios. You could have a desired fractional change from crowding and a desired fractional change from unemployment, which add together to produce the actual fractional change in land zoned for business. [This is one of our building blocks: an "implicit goal-seeking structure."] Land zoned for housing could simply be the rest of the area in the city.

The idea would be that if the laborforce-to-job ratio were above 1 the city would want to zone for more business, so the desired fractional change in land zoned for business from unemployment would be positive.

[If you formulate it this way (and you should!), keep in mind that a fractional growth rate for business land of, say, .05, doubles business land in about .7/.05 or 14 years, and that's very rapid urban change. You would put such appropriate numbers into LOOKUP functions for the desired fractional change from crowding and the desired fractional change from unemployment.]

Your structure should not assume in advance ideal land fractions to zone for business and housing. Instead, it should capture the process by which real pressures push real city actors (voters, city managers, city councils, land use planning commissions) to modify the amount of city land zoned for businesses.

It is conceivable that there is no right mix -- no policy that is politically acceptable for all time. For example, although the desired state might be for the labor and housing ratios to each be 1, that may be impossible in equilibrium (in fact, it's not). The search process might be a never-ending hunt for zoning ratios that would make for a better city, where the criteria for better continuously evolve as people think the grass or the money would be greener with a different mix of housing and business structures.

Show a diagram, an equation list with your changes and additions highlighted, graphs of graphical functions, and runs, with brief commentary.

After thought: Can your zoning policy solve the problem of overshoot and decay shown in the base run of URBAN1?
(2) Adding taxes to URBAN1

Background

URBAN1 does not have an explicit tax sector that raises revenue to support urban services that grow as the city grows and grow even more as the inner-city stagnates and decays. Some claim that urban tax policy can exacerbate the problem of inner-city decay and that enlightened tax policies can cure it. To address such claims with URBAN1, we would have to add a realistic tax sector that determines the revenue the city needs, gets it or as much of it as it can by taxing individuals and corporations, and thereby influences the future relative attractiveness of the city to people and businesses.

Problem

Add structure to URBAN1 to set the tax rate necessary to raise sufficient revenue to support city services.

A good way to proceed would be to compute desired tax revenues from, say, population, or population modified by the Laborforce-to-Jobs ratio (as representing unemployment). The idea would be that each person costs the city something: the total cost would be the desired tax revenue. Formulate the tax rate as a level and obtain the change in that level as a one- or two-year adjustment toward a desired tax rate, as shown at the right.

The Change in Tax Rate in this bit of model structure equals (Desired Tax Rate - Tax Rate)/Time to Adjust Tax Rate.

Tax planners would figure the desired tax rate from the existing tax base and the desired revenues, and you should be able to figure out how they would do that.

If the tax base is $10 million and the desired tax revenue is $1.5 million, then the desired tax rate is 1.5/10 or 15 percent.

The tax base could be computed simply in this URBAN1 model as property — business structures and housing structures each with some assessed valuation for each type (constants for simplicity) — or if you prefer, business income (proportional to business structures) and personal income (proportional to the working population). Assume that the tax revenues raised are spent (that is, don't bother with a level of "cash on hand.") Run the model at this point. Since you haven't closed any loops on people and structures, it should behave just as before, but with the new variables you've added. Adjust new parameters to make it look reasonable (don't change any original parameters).

Closing loops: The size of the urban tax rate(s) would influence the flow of new businesses and people into the city. You should formulate these effects in graphical functions similar to the Attractiveness of Jobs and the Attractiveness of Housing. [What are the polarities of the feedback loops these influences create?]

Show a diagram, an equation list with your changes and additions highlighted, and a run with taxes and their influences active, with brief commentary. Comment on how taxes influence the base run of the URBAN1.