

## 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.

### Guidelines:

- *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 adding complexity 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.

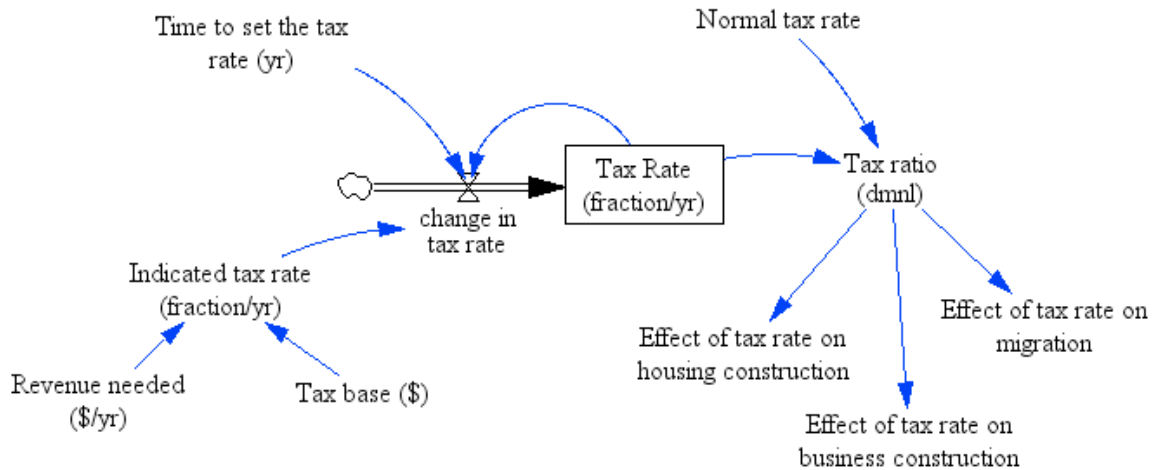
## Adding taxes to URBAN1

### *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. Begin with the following structure (but add only bits of it as you go -- always have a running model):



The structure captures the Tax Rate as a stock. It assumes that it takes time to determine and decide on the tax rate. So the change in tax rate in this bit of model structure equals  $(\text{Indicated Tax Rate} - \text{Tax Rate}) / \text{Time to Set the Tax Rate}$ . That time constant would probably be one or two years.

You should decide how to formulate *Revenue needed* and the *Tax base*. Revenue needed could be proportional to Population (as in the city services needed to support the population). The tax base could be the assessed value of business structures and housing structures, as would be the case if the city had a property tax. (For simplicity, use constants for the assessed value of the average business structure or housing structure.)

[Alternatively, the tax base could be proportional to Population, or better the Labor Force, as if the city had an income tax. The revenue needed could be proportional to business structures and housing structures, thinking that the city expenses would have a lot to do with the property in the city. It's your choice. But keep it simple: constants times stocks.]

Tax planners would figure the tax rate they need (the "indicated 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. (Pick your constants for revenue needed per

capita and the tax base so that the Indicated tax rate comes out to the “normal tax rate,” 10% or 15% in initial conditions.)<sup>1</sup>

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 or structure!).

Closing loops: The size of the urban tax rate 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?]

Operate like a scientist when you close these loops. First formulate the graphical functions for these effects with 1's all the way across -- the “no effect” value. Then put in values in just one of the effects to make it active; keep the others inactive. Proceed with the other effects. Learn as you go. Eventually make all three of the effects active, with graphical functions you think make sense.<sup>2</sup>

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

Subtleties: Once you have your model running and loops closed and it makes sense, you could think about some subtleties, if you want. For example, the city might need more revenue if it has high unemployment (needing more social services) or a lot of abandoned housing (the households-to-housing ratio gets low) or the city is in its mature heavily built-up phase (land fraction occupied near 1) and things like the crime rate go up, requiring more city services. But don't try to do any of these until you are all done with the basic assignment!

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<sup>1</sup> Note that you could have the model calculate the revenue generated by the tax rate that gets determined (tax rate times tax base), but you don't need to do that. To keep things simple, we won't add to the model a stock of city cash. If we did, its inflow would be revenue and its outflow would be expenses. But we'll ignore that, assuming instead that the revenue generated gets spent -- hence, no stock of cash to worry about.

<sup>2</sup> Show your graphical functions in your homework: you can get a nice little graph by selecting one of the effects and obtaining a strip graph for it -- the graphical function will show up as one of the graphs you get. Copy and paste it into your assignment.