Instructions for Tutorial 4

Modelling of Systems for Sustainability

3rd October 2024

1 Aim

The aim of this Tutorial is to get practice in formulating models collaboratively, which could be helpful for the Project.

2 Before the tutorial

There is no special preparation required, apart from to have attended the lectures on formulating models and system dynamics. The first chapter of Meadows (2008) could be helpful background.

3 In the tutorial

In small groups we would like you to start the work of formulating a model of a system that you are all reasonably familiar with. We suggest that you work on the food system: how food is produced from the farm to the plate. However, if on your table you have a system that you are familiar with, it would be fine to work on that model.

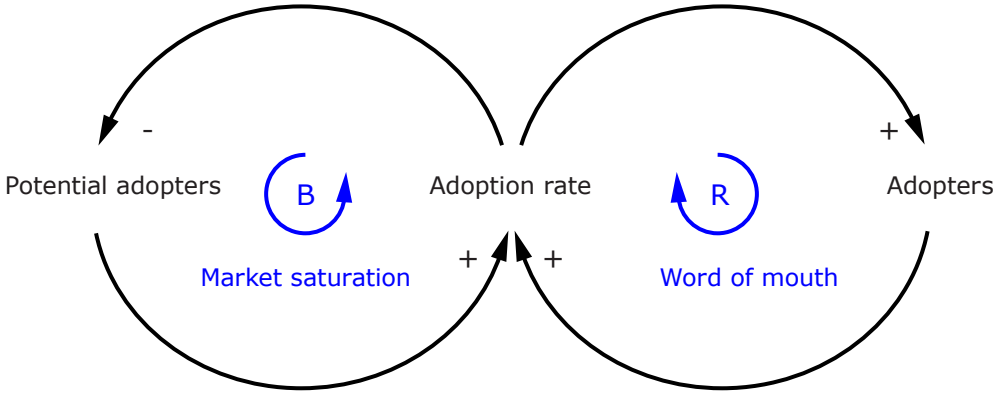
In Lecture 2, on the modelling cycle, the first two steps of the modelling cycle were:

1. Formulate the question
2. Assemble hypotheses for essential processes and structures

We are going to focus on the second of these points. However, it is useful to have a question that the model would address. For the food system, we suggest that the question the model addresses is how the system could be changed so as to minimise food waste, while still maintaining an adequate supply. You might want to focus on Scotland or the UK, or you could try to think of another part of the world, or globally. It doesn't matter too much exactly what answer you get; the main thing is to get practice in thinking about how entities are connected.

To formulate the question, we suggest the following:

1. Use the whiteboard to draw an influence map or causal loop diagram of a model of the system could be. The causal loop diagram format contains factors/entities, linked by directional arrows, with the effect of each arrow indicated by a "+" or "−"; see example below of technology adoption (credit: Apdevries, Wikipedia, CC BY-SA 3.0)



For example, as quantities you might have "crops", "farm animals", "food stores" and "consumer demand". Higher levels of crops will lead to larger harvests and therefore larger food stores.

2. You will need to decide where the boundaries of your system are. For example, do you need to include weather systems?

3. In this diagram, try to identify any reinforcing or balancing feedback loops. The reinforcing loops (also referred to as positive feedback) are the ones where the effect of the loop amplifies the effect: e.g., more adopters lead to a higher adoption rate, leading to more adopters. The balancing loops are the ones where an increase in a quantity in one part of loop leads to downward pressure on that quantity, thus balancing out the initial increase, and ultimately pushing the quantities to steady values.

4. The next stage in modelling might be to decide on whether to implement the system in an agent based or system dynamics format. Consider what the pros and cons of both approaches might be in your group.

5. If there's time, start translating your diagram to the system dynamics or agent-based formalism.

    - If system dynamics, we suggest drawing a stocks and flows diagram, and putting in some potential equations for the flow rates. It's probably a good idea to start on one corner of the system.
    - If agent-based, we suggest you identify the entities (which will be closely related to the qualities in the causal loop diagram) and describe the interactions between the entities.

6. At the end we'll look at the work of each group, and reflect on how the process formulation process went.

References

Meadows, D. H. (2008). *Thinking in systems: a primer*. Chelsea Green.