Click https://vimeo.com/729809366?&login=true link to open resource.

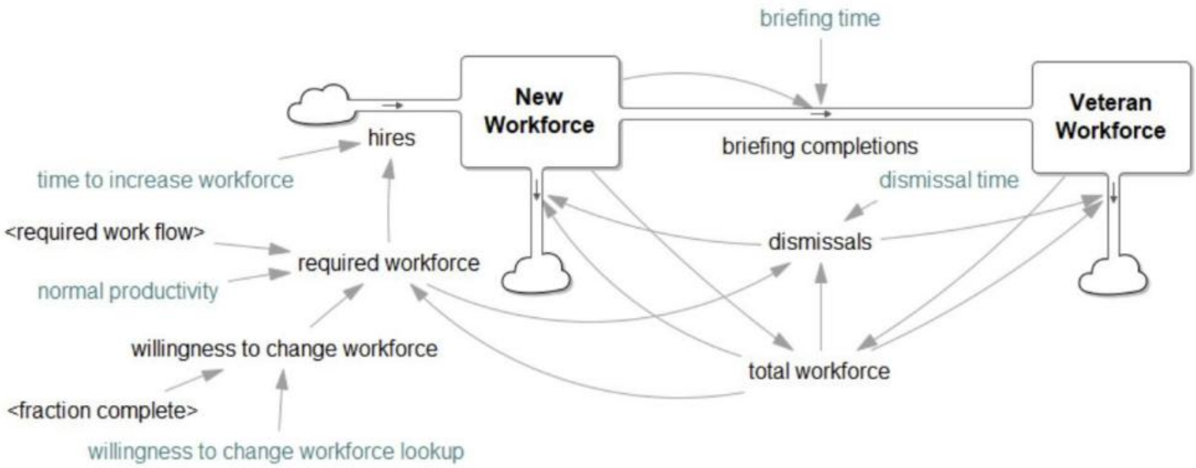
Introduction to System Dynamics and Simulation Modelling base on Vensim software

- '*system*' means a set of independent elements that interact with each other in a stable way.
- The system is a set of interrelated elements, where any change in any element affects the set as a whole.
- System Dynamics aims to gain understanding of the structural causes of a system's *behaviour*.
- How do we represent the system?

The Causal Diagram

- The causal diagram represents the key elements of the system and the relationships between them.
- This diagram shows the relationships as arrow between the variables

The Causal Diagram



The Causal Diagram

- These arrows are marked with a sign (+ or -) which indicates the kind of influence one variable exerts over the other.
- A "+" means a change in the influencing variable will produce a change of the same direction in the target variable.
- A "-" means the effect will be the opposite.

The Causal Diagram

- So, when an increase in A results in an increase in B, or a fall in A causes a fall in B, this is a positive relationship, as shown below:

The Causal Diagram

- When an increase in A results in a fall in B, or a fall in A causes an increase in B, this is a negative relationship, which is expressed as follows:

Examples of systems. Exponential Growth

Suppose that you deposit $100 in the bank.

If the interest rate is 10% per year and you wait 100 years what will happen?

Key elements of the system are:
deposit, interest rate, interest, money

deposit

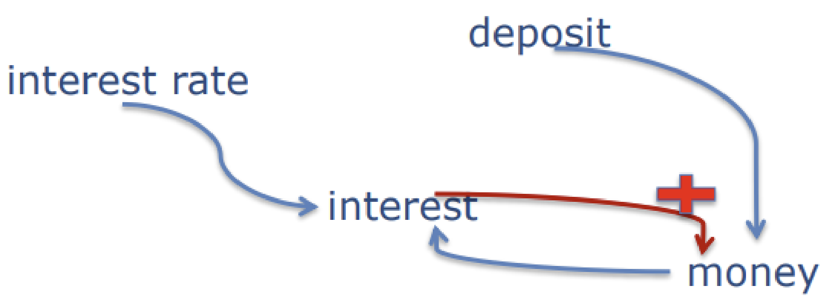
interest rate

money

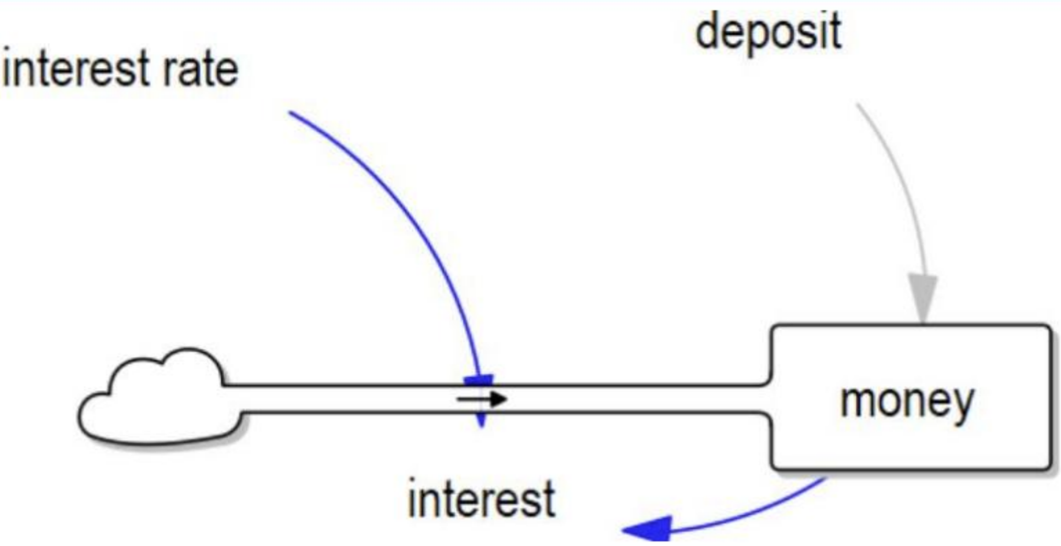
interest

1. Exponential Growth

Relationships between key elements of the system:



Model of Exponential Growth on Vensim



deposit=100
interest=money * interest rate
interest rate= 0.1
money= INTEG (interest,deposit)

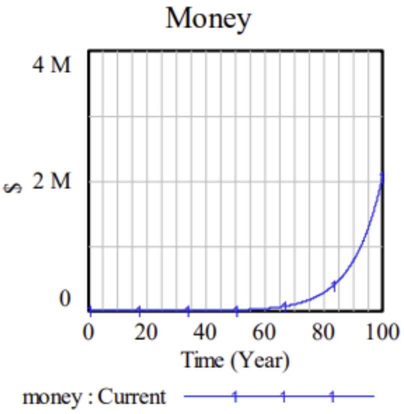
Model of Exponential Growth on Vensim

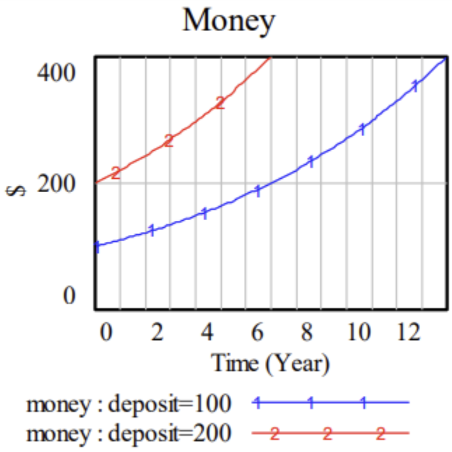
There are 2 main questions we can ask:

1. The first is what is the doubling time? How many years we need to wait to go from 100 to 200?

2. Is this time depends on initial value of deposit or not and it is a constant?

Model of Exponential Growth on Vensim





Exponential growth is interesting because it demonstrates a constant doubling time. If it takes, as it does in this example, about 7 years to go from 100 to 200 dollars, it will also take about 7 years to go from 1 million to 2 million dollars

2. Exponential Decay

Suppose that somebody deposit to you 10000$ but each year you can get only one tenth part of the rest money.

What will happen to your deposit?

Key elements of the system are the same: deposit, interest rate, interest, money

deposit

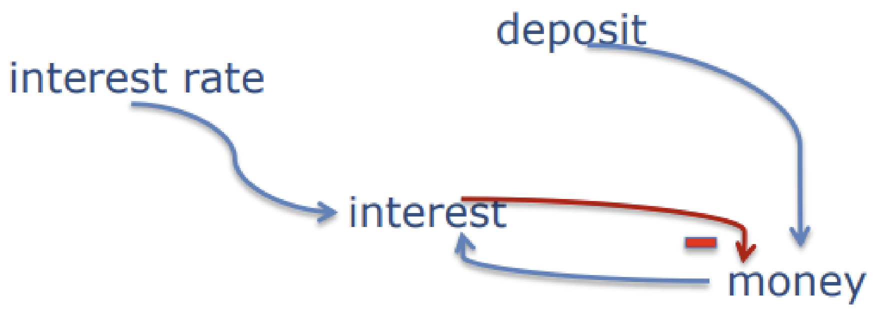
interest rate

money

interest

2. Exponential Decay

Relationships between Key elements of the system are the same but:



Instructions to Modeling

Phase I: Influence diagram

1. Formulate a verbal model of the relationships important to the system's dynamics.
2. Identify the system quantities necessary for the system description.
3. Use the information from Steps 1 and 2 to draw the corresponding influence diagram (causal loop diagram). (Steps 1 to 3 can be executed at the same time.)
4. Identify (in the diagram) those system variables which are best used to describe the behavior of the system.
5. Give an intuitive assessment of the development of the system for alternatives A and B, and sketch the expected time plot for key variables identified in Step 4.

6. Report your model concept in plenum and explain your expectations concerning the system's dynamics.

Note: If ecosystems remain undisturbed over a long period of time, they develop in the direction of a mature state (climax), i.e. a dynamic equilibrium which corresponds to the ecological carrying capacity of the region.

Instructions to Modeling

Phase II: Simulation diagram

7. Identify in your model system: (1) state variables, (2) system parameters, (3) exogenous quantities, (4) rates of change of state variables, and (5) intermediate variables.
8. Modify the influence diagram by introduction of the symbols for the different types of system quantities (new diagram!)
9. Specify what type of mathematical operation is to be performed to compute a given quantity (integration, addition, multiplication etc.).
10. Formulate the corresponding mathematical relationships (formulae or functions) that allow the computation of each variable from its input variables (and time).

11. Check whether all quantities can be calculated in the resulting simulation diagram.
12. Present the simulation diagram in plenum for discussion.
Note: Since accurate empirical data are not available, and only the qualitative properties of the dynamics are of interest, use relative (normalized) quantities having a reference value of "1" for the initial system state.

Instructions to Modeling

Phase III: Simulation
13. Implement the model using a suitable program for computer simulation (including numerical integration of state variables).
14. Quantify the model for the two alternative scenarios A and B.
15. Simulate dynamic development for both cases.
16. Compare the results with your previous intuitive assessment (Step 5).
17. Change and adjust system structure and parameters (within realistic limits only!) until you are relatively certain that the model describes actual dynamics reasonably well.