

System Dynamics Tools I

Problem Definition Introduction to Causal Mapping

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Paulo Gonçalves

Università
della
Svizzera
italiana



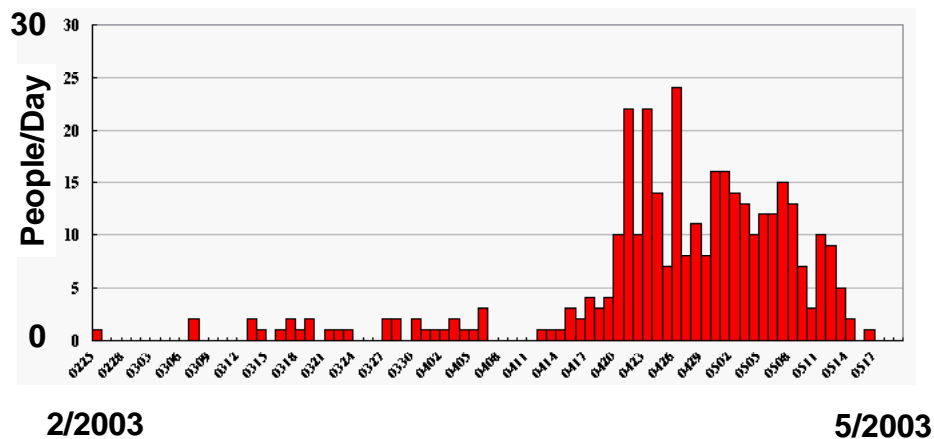
Systems Thinking View Point

- **Traditional mental models:**
 - Seek for causes located close in time and space to events
- **Systems Thinking Perspective**
 - Structure generates Behavior
- **Tools for Systems Thinking**
 - Dynamic Problem Definition (Reference modes)
 - Causal Loop Diagrams
 - Fundamental modes and generative structures

Dynamic Problem Definition

- Problem definition:
 - Main concern trying to address
- Identify important concepts and variables:
 - Model boundary chart
 - List endogenous, exogenous and excluded variables
- Time horizon:
 - How far back in time and into the future to capture long-term effects of policies
- Reference modes:
 - Graphically characterizes patterns of problem behavior over time

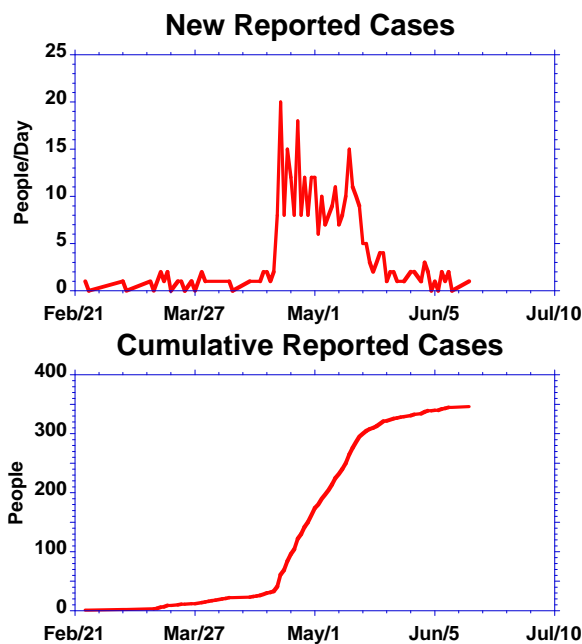
SARS in Taiwan — Incidence (Probable Cases Reported per Day)



Dynamic Problem Definition

- Problem definition:
 - Diffusion dynamics for spread of SARS in Taiwan.
 - Causes of dynamics and possible policies to stop it.
- Identify important concepts and variables:
 - Incidence, prevalence, contact rate, infectivity, deaths, cumulative cases
- Time horizon:
 - Fast spread disease.
 - From first probable case to months after last one.
- Reference modes:
 - Behavior over time for reported cases, cumulative cases, incidence, and prevalence.

The Reference Mode

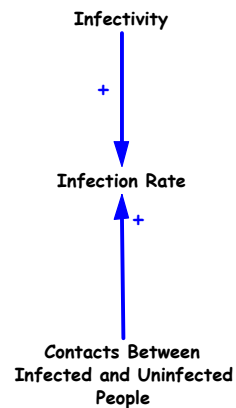


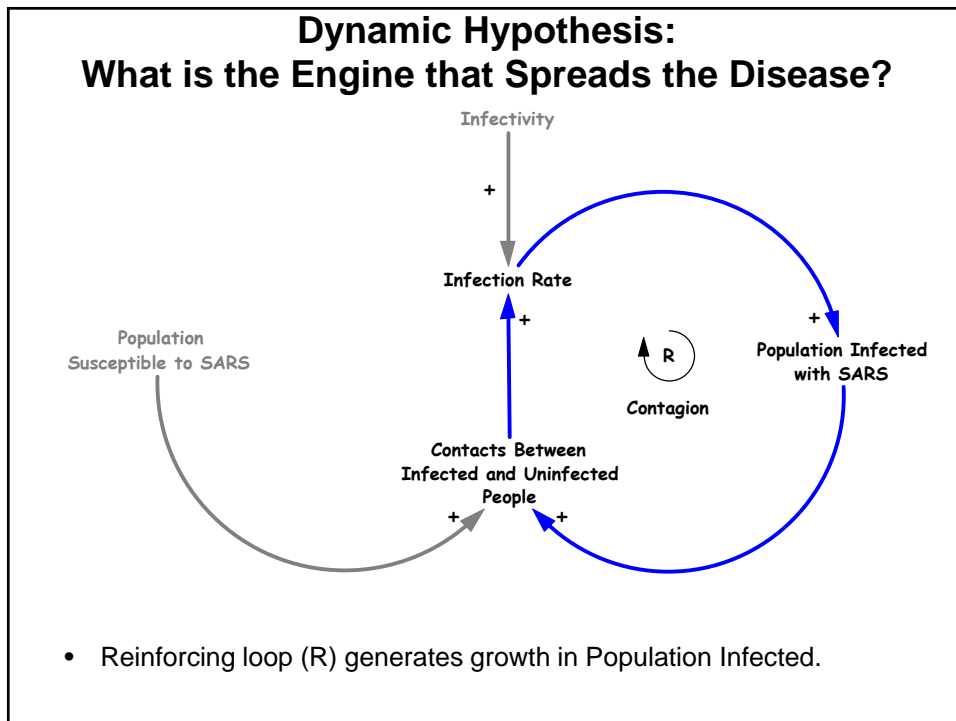
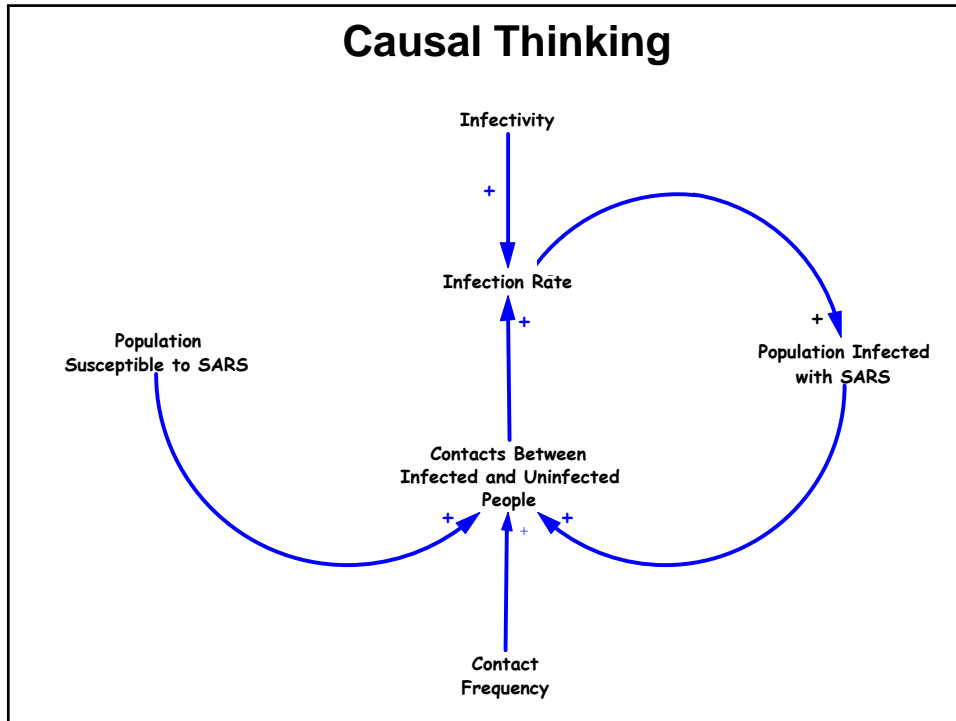
SARS displays the classic “s-shaped” growth pattern associated with the diffusion of infectious diseases (and new products, innovations, etc. etc).

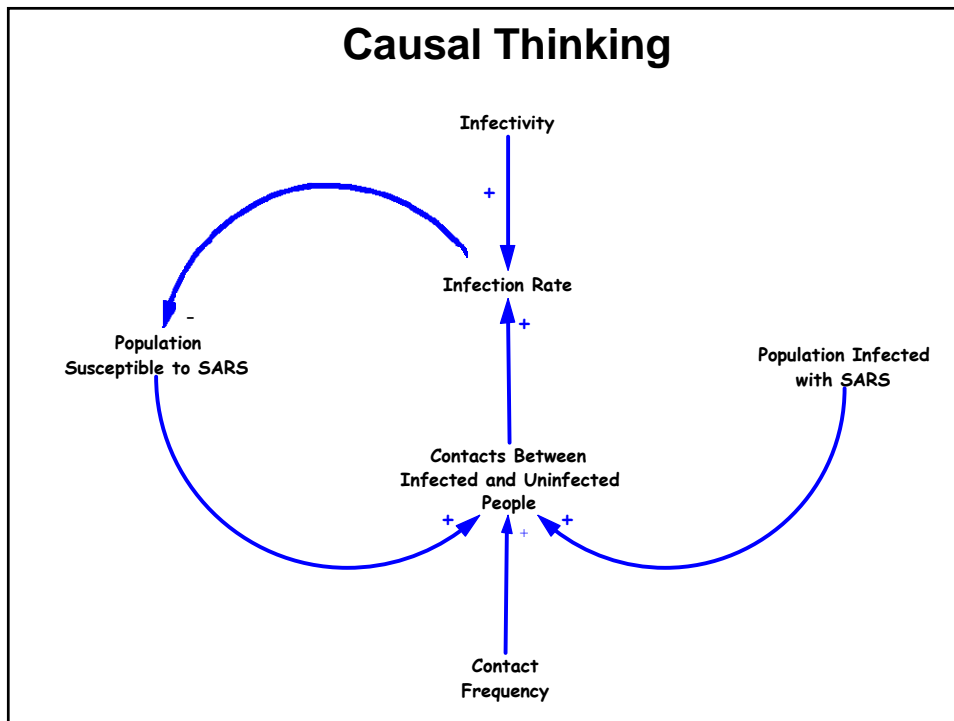
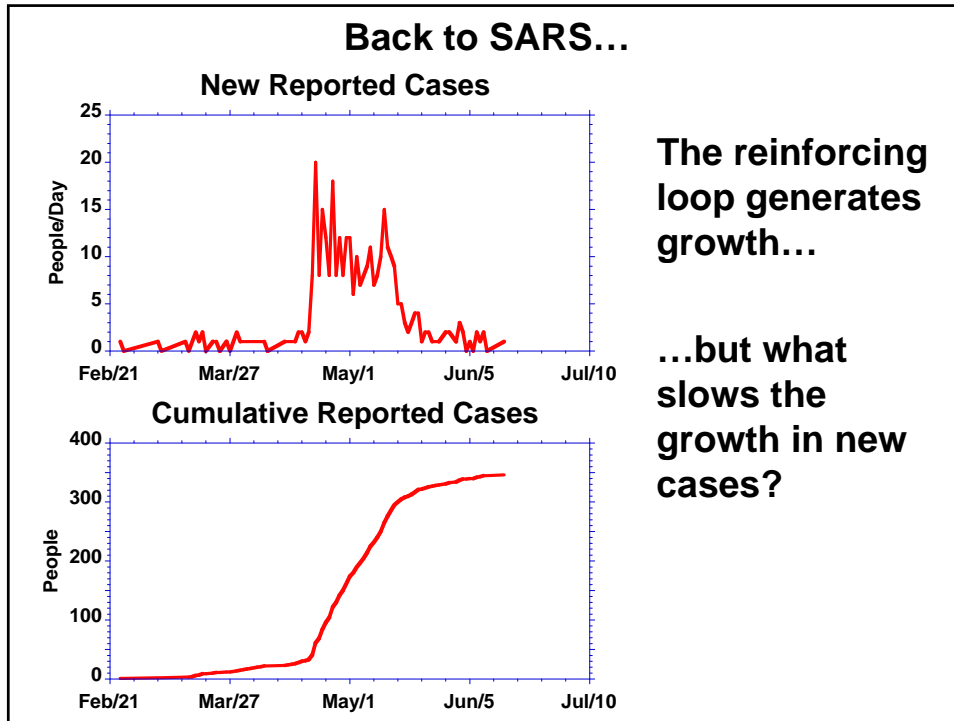
Important Concepts & Variables

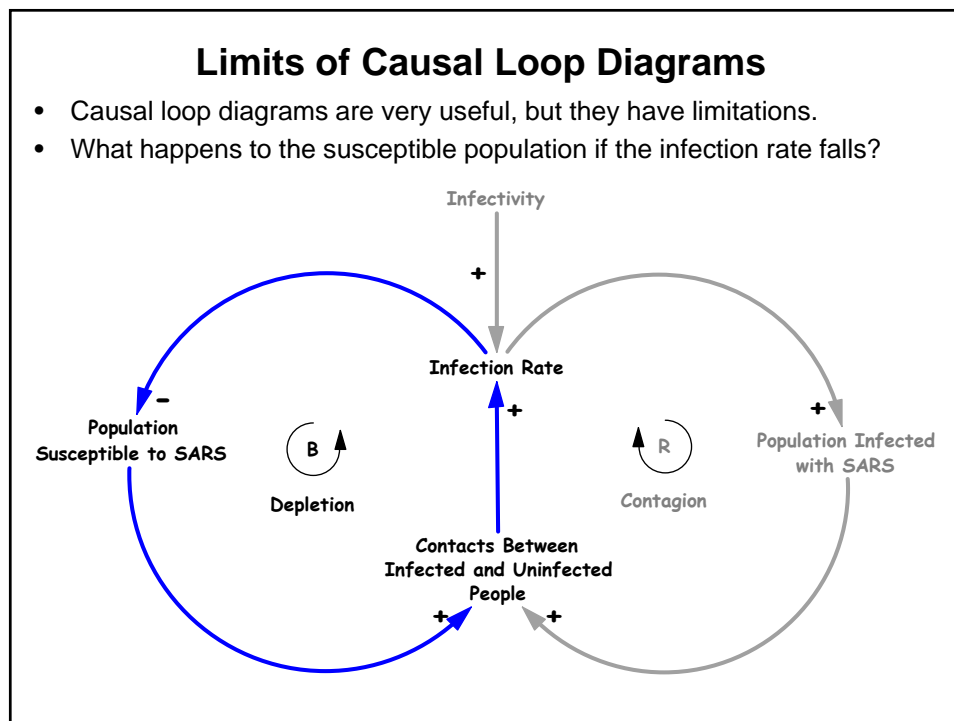
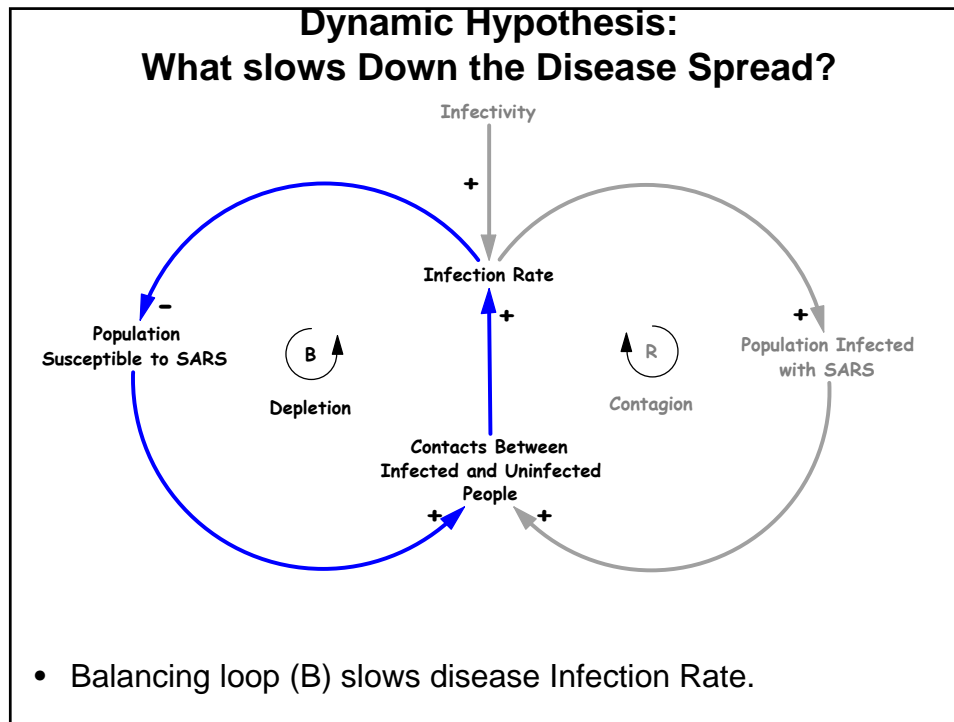
- **New Reported Cases:**
 - Not the same as **Incidence**.
 - Not all sick people report to hospital.
- **Cumulative Cases:**
 - Not the same as the **Infected Population (Prevalence)**.
 - Some sick people recover, others die.
- What influences Incidence (or Infection Rate)?
 - SARS spreads through human contact

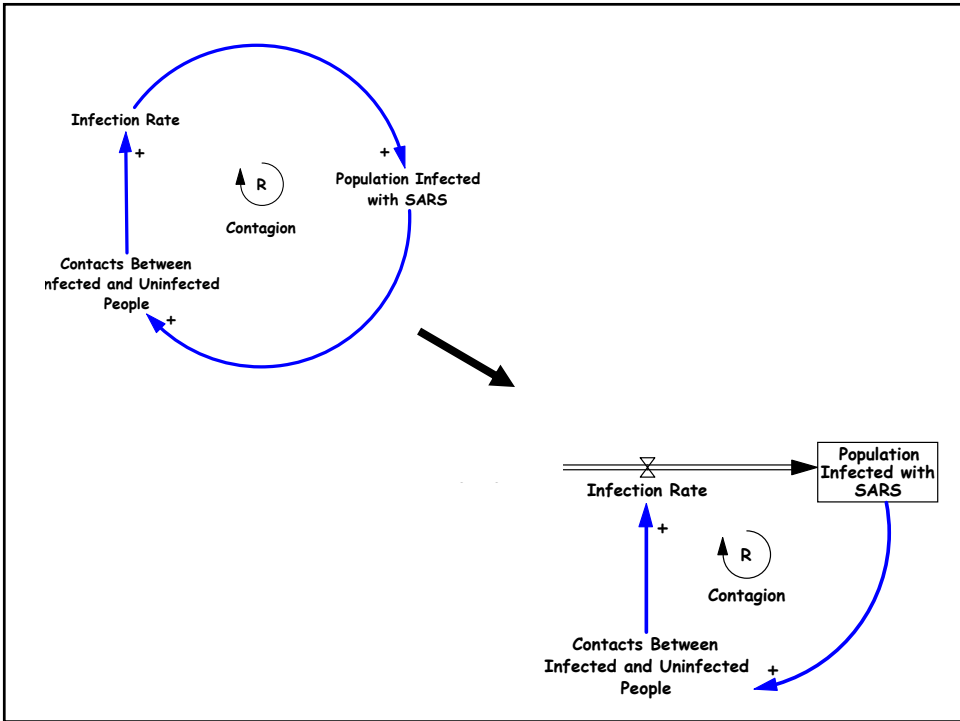
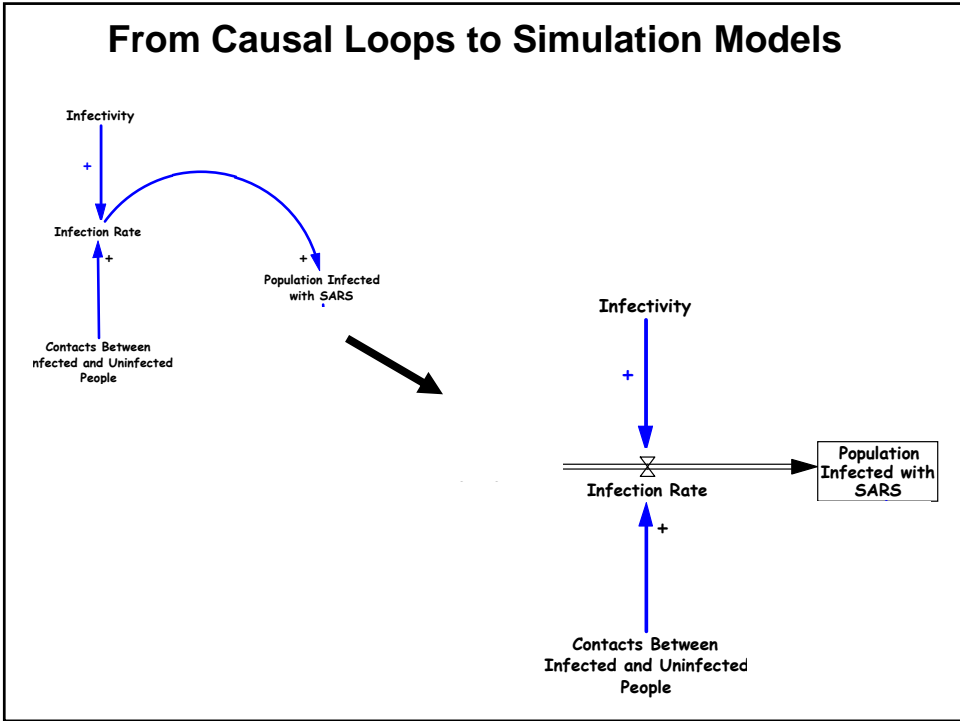
Causal Thinking

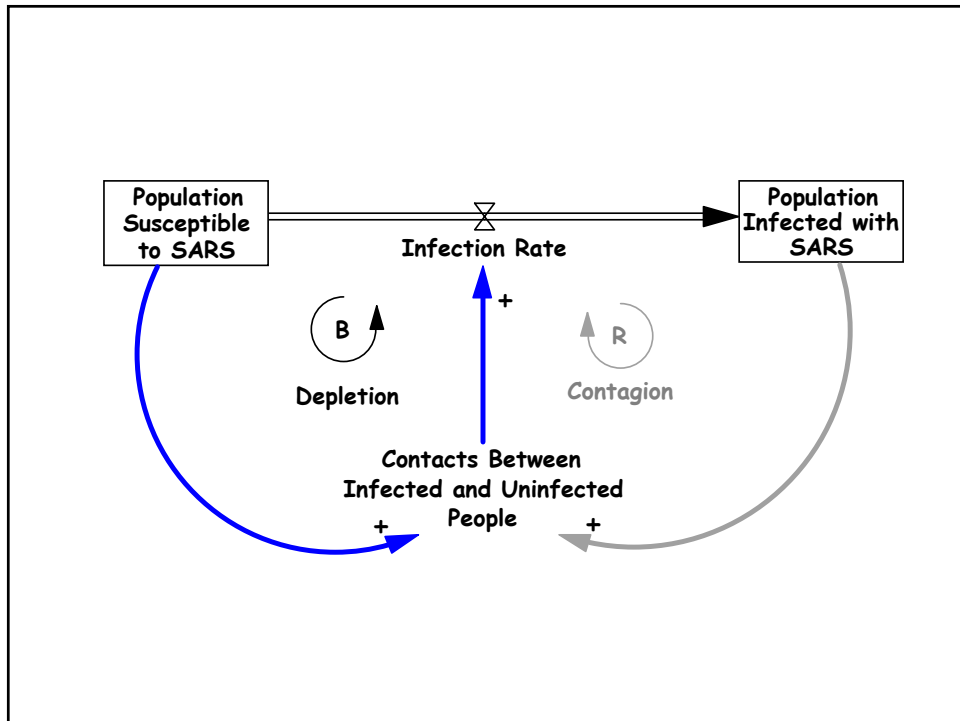
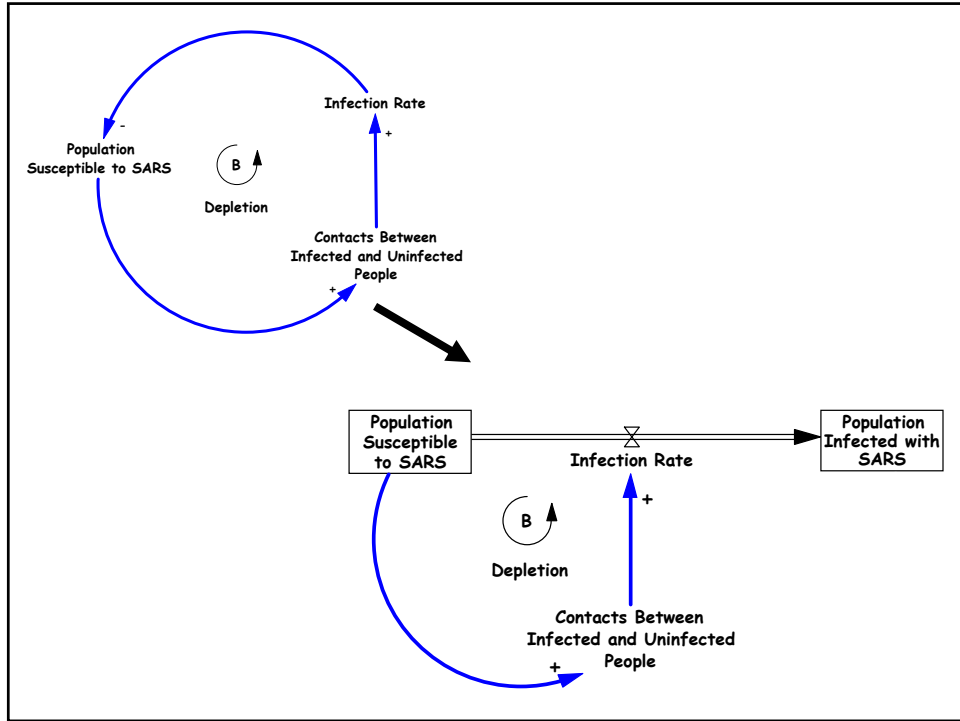








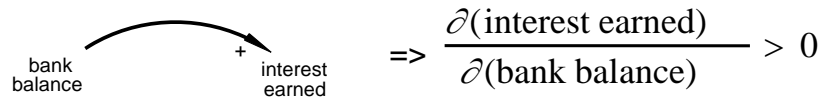




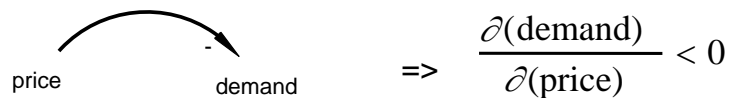
Causal Links Definition and Practice

Causal Links

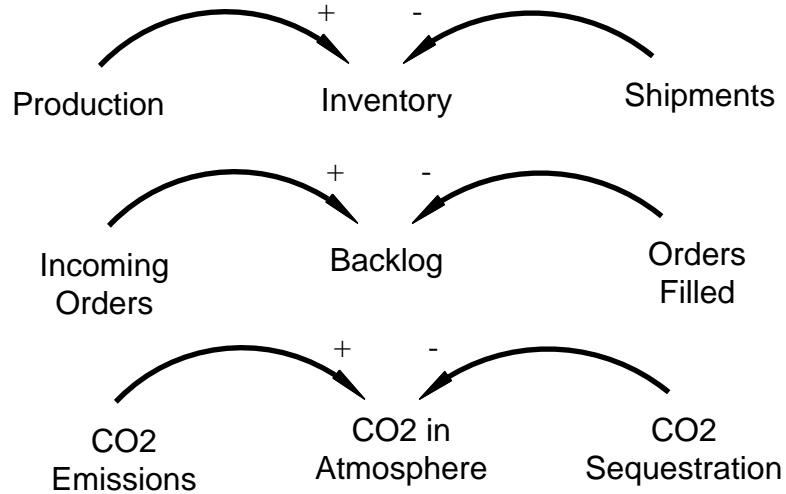
an arrow with a positive sign means that, *all else being equal*, a change in the first variable *causes* a change in the second variable in the same direction.



an arrow with a negative sign means that, *all else being equal*, a change in the first variable *causes* and change in the second variable in the opposite direction.

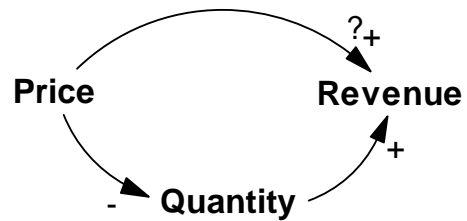


Practice with Causal Links



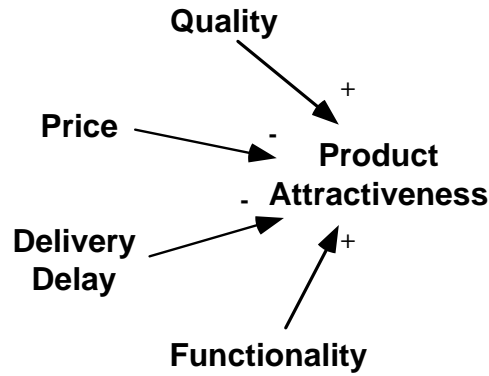
Causal Links

- What happens when a link has an ambiguous sign?

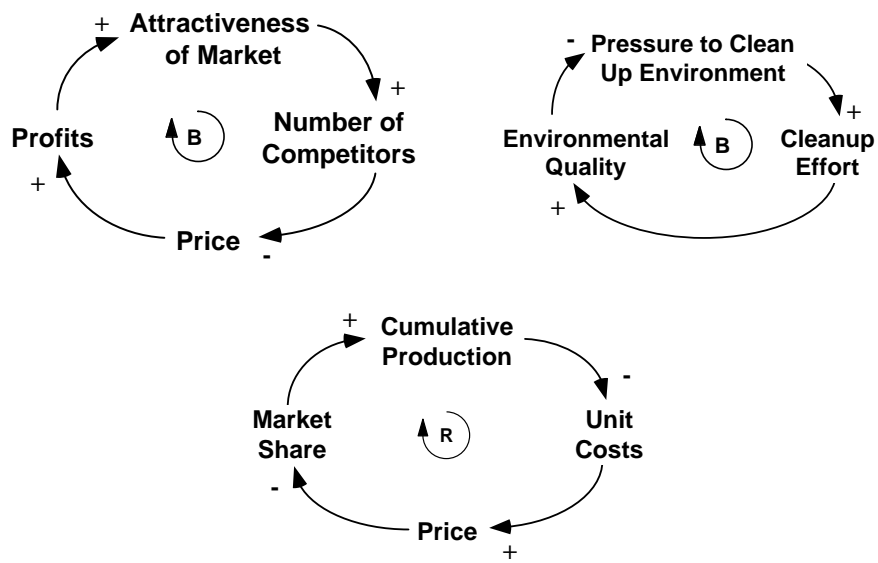


$$\text{Revenue} = \text{Price} * \text{Quantity}$$

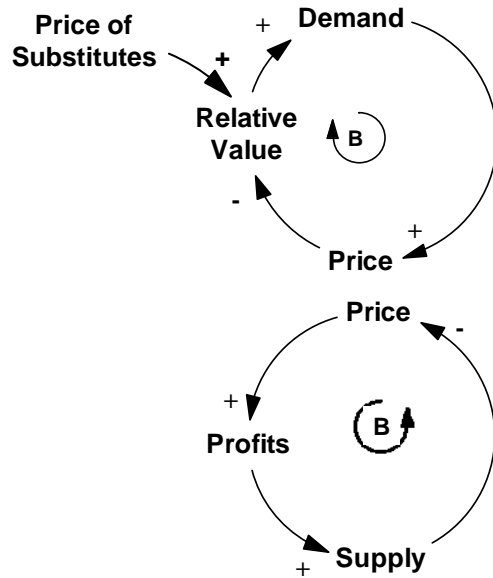
Several Causal Links Can Impact Single Variable



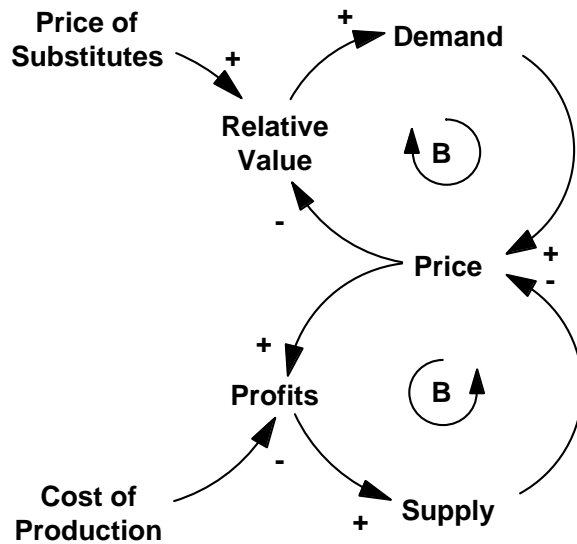
Practice with Causal Loops



Practice with Causal Loops



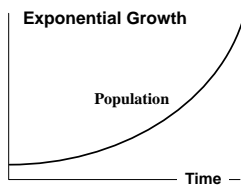
The feedback structure of markets



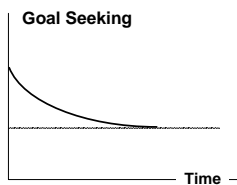
What patterns of behavior do we observe in general? In logistics?

Patterns of Behavior

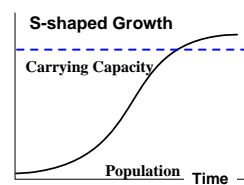
Demand for Successful Product



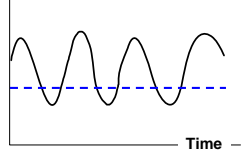
**Cost Reduction
Delivery Delay**



**Quality
Logistic Efficiency**

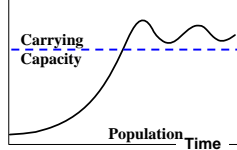


Oscillation



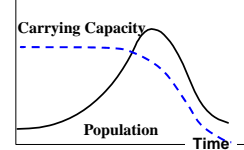
Inventory, Demand

Growth with Overshoot



Client Satisfaction

Overshoot and Collapse



Product life-cycle