Economic Dynamics

David Wheat, PhD, MPP

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Lecture 1: Introduction to Dynamic Modeling

September 16, 2021

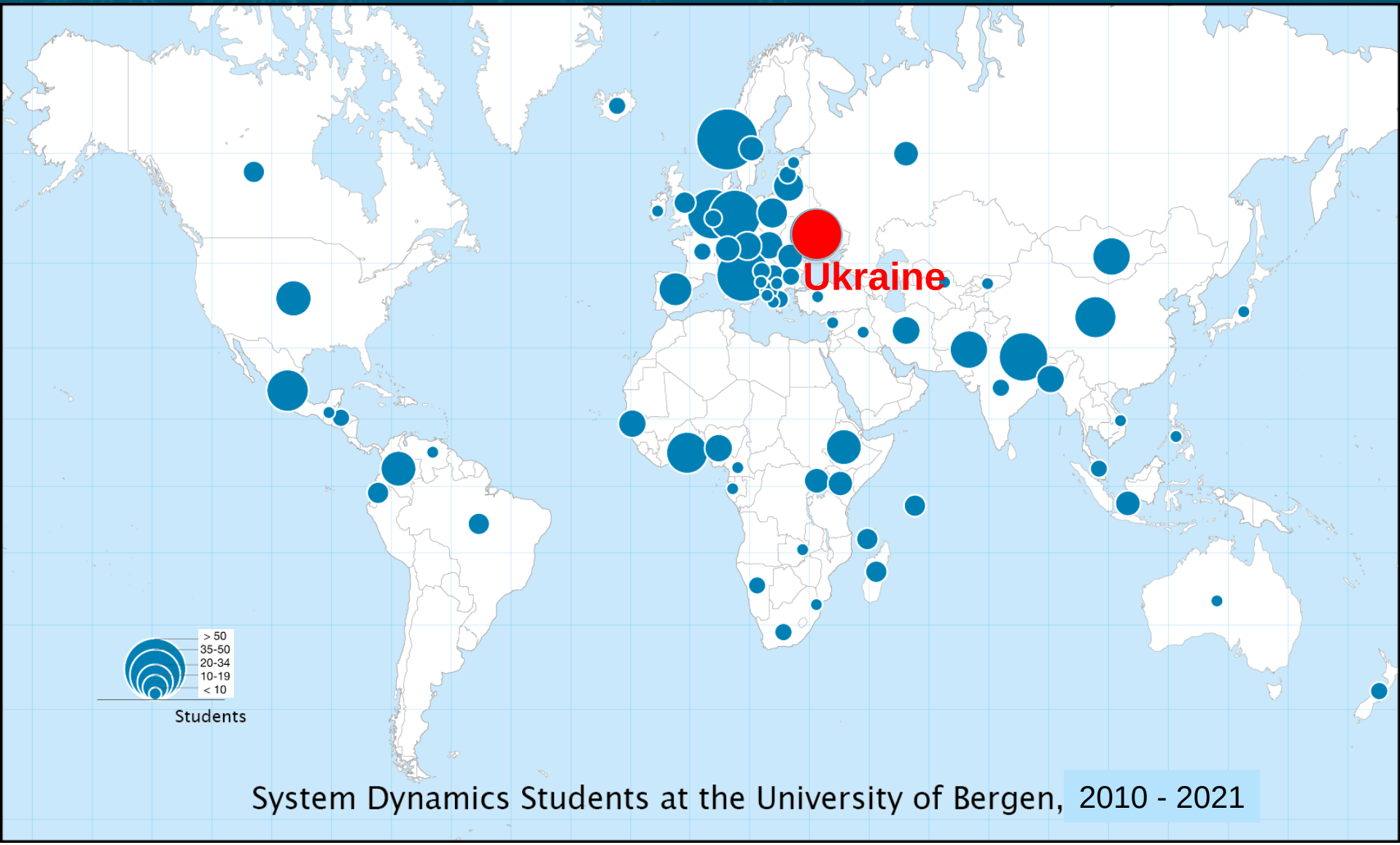
Professor
ISM University, Lithuania

Professor
Virginia Western College, USA

UNIVERSITETET I BERGEN

System Dynamics Group

Ukrainian SD Students in Bergen



Learning Economics with Dynamic Modeling

Project (2012-2022) funded by Norwegian Foreign Ministry

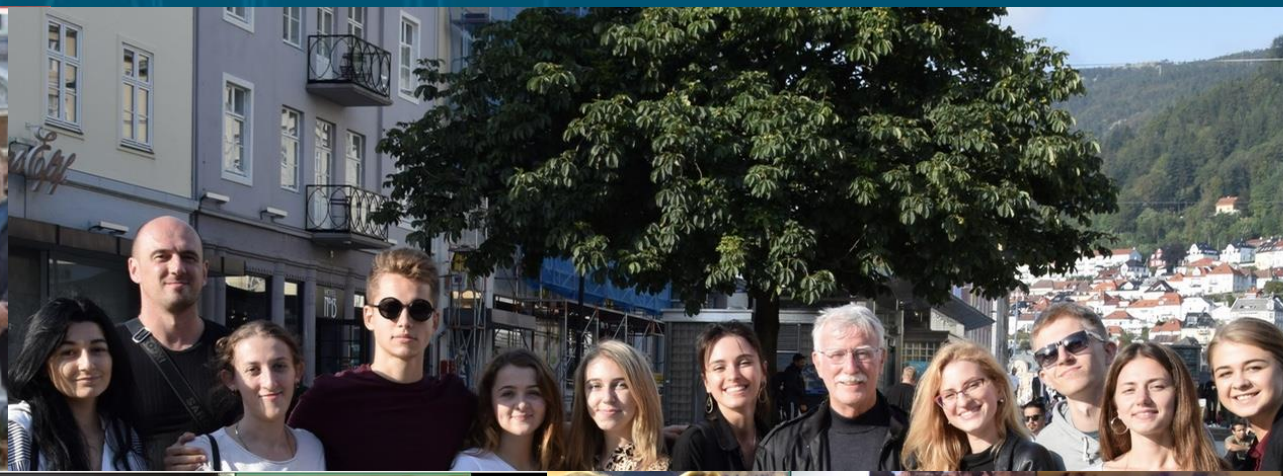
Goal: Develop Dynamic Modeling Capacity at NaUKMA (finance dept.) & LNU (mathematical economics dept.)

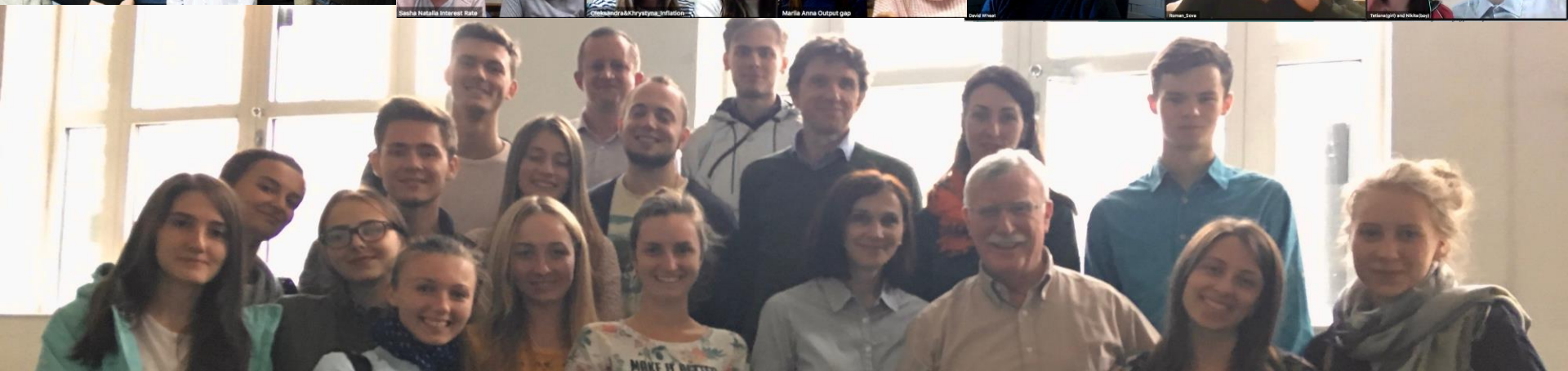
Strategy: Train the Trainers

Outcomes: 100+ students & professors trained in SD
1 new SD course at Bergen for NaUKMA & LNU
4 new SD-based courses at NaUKMA & LNU
collaboration with National Bank of Ukraine, Ministries: (1) Economy, (2) Reintegration.

NaUKMA & LNU at University of Bergen

(only since 2016)





About the Course

Course Description: This course introduces basic principles of economic dynamics and compares static models with dynamic models. Emphasis is on the 'source' of dynamics: where is THIS dynamic behavior coming from?

Course Prerequisites: None.

Course Objectives: To enable students to…

- Distinguish between static and dynamic economic models;
- Compare correlational models and causal models;
- Develop basic skills in system dynamics modeling.

Instructional Methods

This is mostly an online course, using Zoom.

All lectures are supplemented by reading assignments, tutorials, and modeling exercises.

Onsite computer lab sessions will provide opportunities to improve skills introduced during the lectures & assignments.

All assignment deadlines will be decided by Alina & Marianna.

Materials

READING

Sterman: *Business Dynamics* (2000)

Other reading material will also be assigned.

SOFTWARE

System Dynamics simulation software

- *Stella Architect,* version 2.1.3
- individual student licenses
- each of you enrolled in the course should have an account
  -- download, install, & get acquainted

Lectures: Thursdays, 16:30-17:30

Sep 16	**Introduction to Dynamic Modeling**	
Sep 23	Simplified 'Three-Equation Model'	
Sep 30	Add Money to the Model	
Oct 7	Monetary Policy: Exogenous Friedman Rule	
Oct 14	Monetary Policy: Endogenous Taylor Rule	
Oct 18-27	—- autumn break—-	
Oct 28	Add Banking Sector to the Model	
Nov 4	Add Central Bank to the Model	
Nov 11	Add Foreign Sector to the Model	
Nov 18	Review & Test of the Model	
Nov 19- Dec 16	Study for Final Exam	

lab dates to be announced, by **Alina Novik** and **Marianna Oliskevych**

Assignments
due before next lecture

1. Practice with *Stella Architect* -- on your own.
2. Study SD supply-demand models: 2.1 and 2.1a (will be sent to you).
3. Read: (a) ***Wheat & Oliskevych;*** *(b)* **Sterman** pp. 300-314
4. Study online model: https://exchange.iseesystems.com/public/david-wheat/sd-nk/index.html#page1
5. Be prepared to discuss your assignments.

Send all written assignments to Alina (NaUKMA), Marianna (LNU), and me

novikaj@ukma.edu.ua olisk@ukr.net david.wheat@uib.no

*Use this format for file names:

LastNameFirstName YYMMDD e.g., HarrisEmmylou 210916

zip all files before emailing

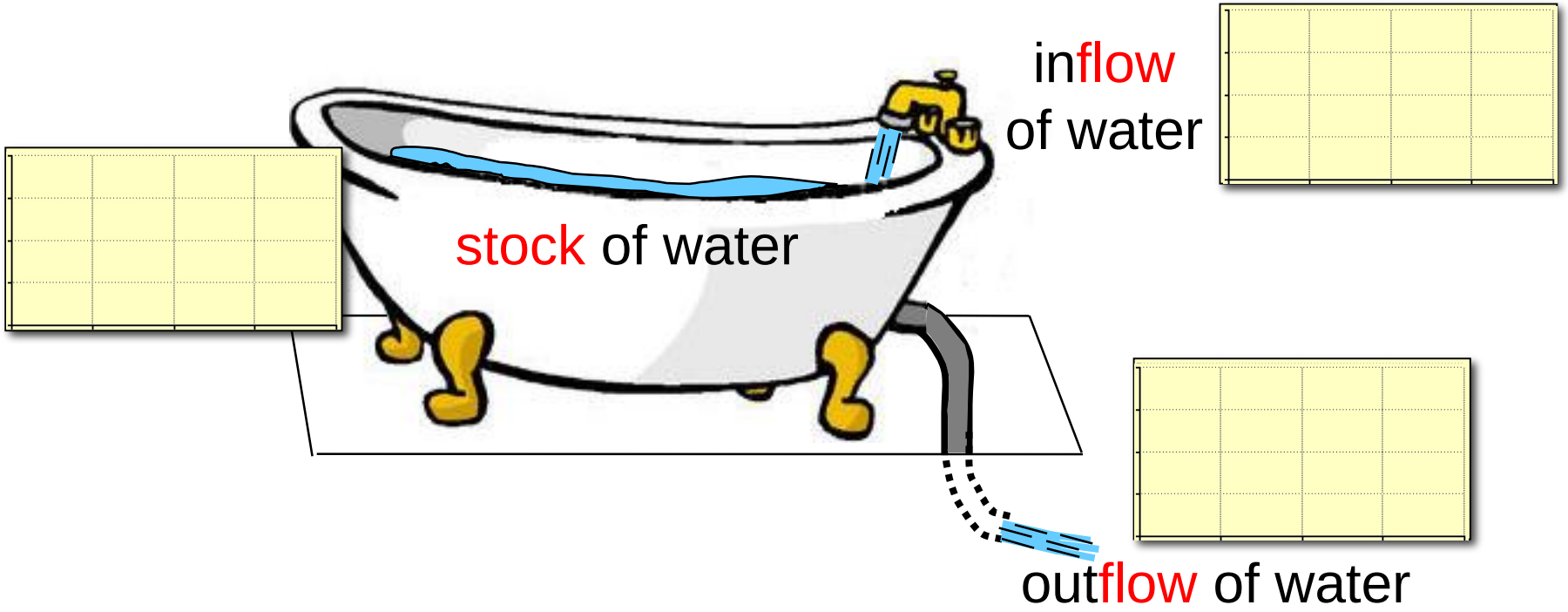
System Dynamics

A simulation modeling approach to the *study* and *management* of dynamic problems in socio-economic systems.

Key Concepts:

- Structure: stocks and flows
- Behavior: (1) levels of the stocks and (2) rates of the flows

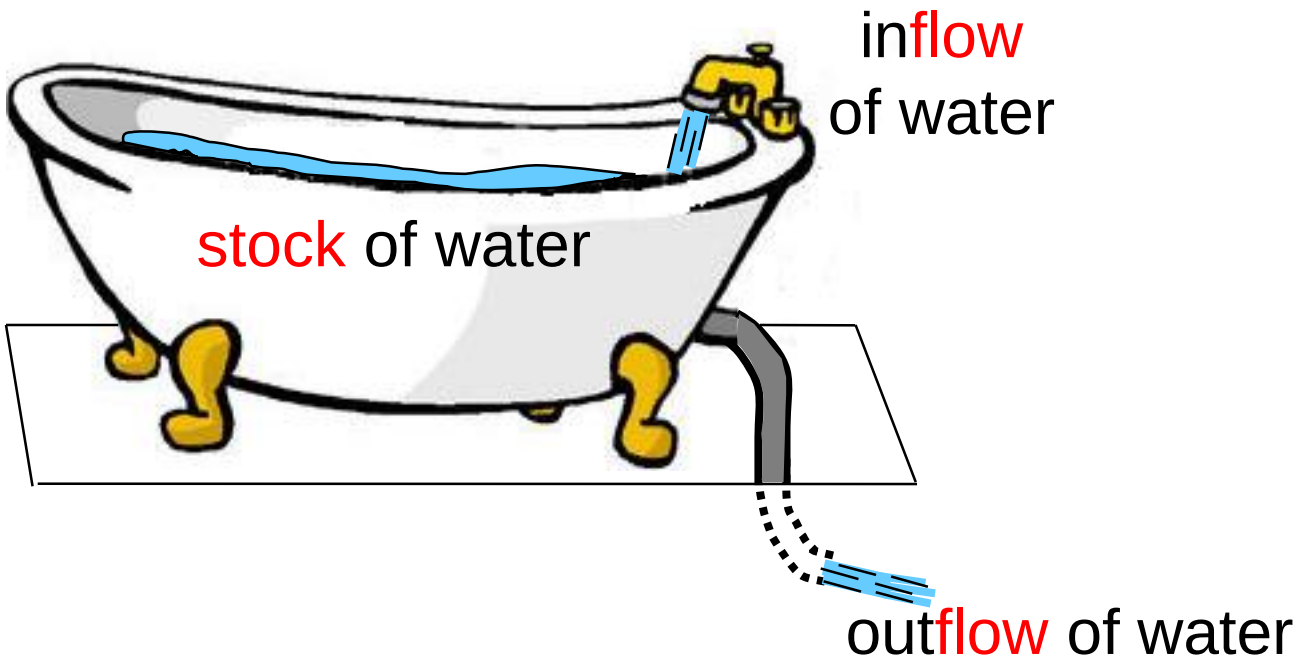
Structure and Behavior



The stock of water depends on inflows and outflows.
Explanatory model should explain what causes the flows to change.

How are these similar to water-in-a-bathtub?

patients in a hospital?
money in a bank account?
students in a university?



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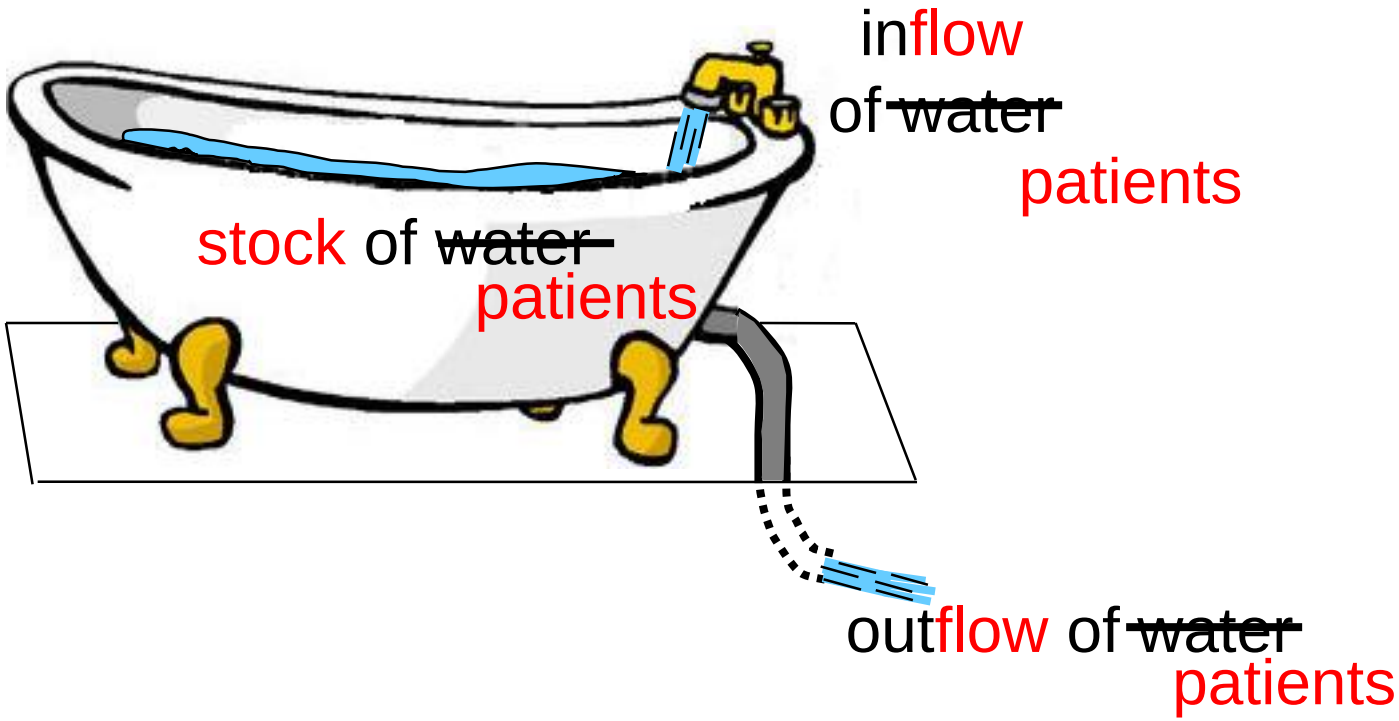

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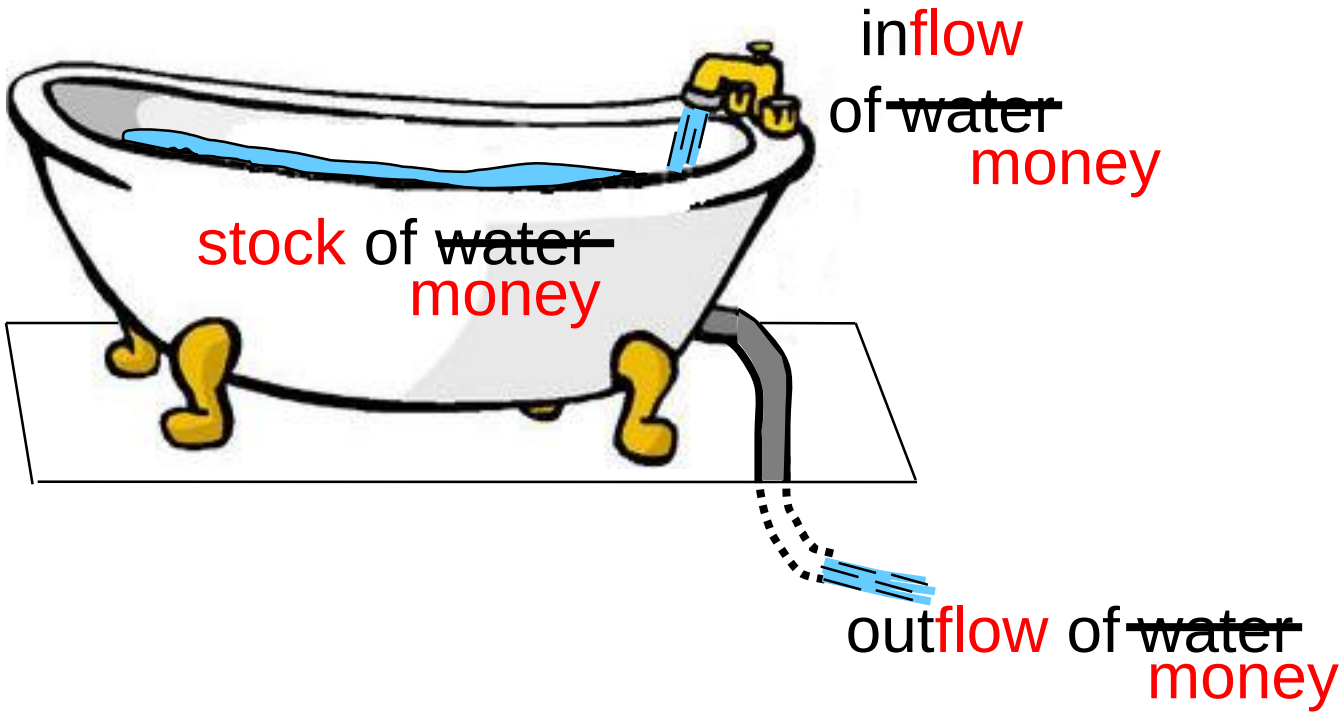

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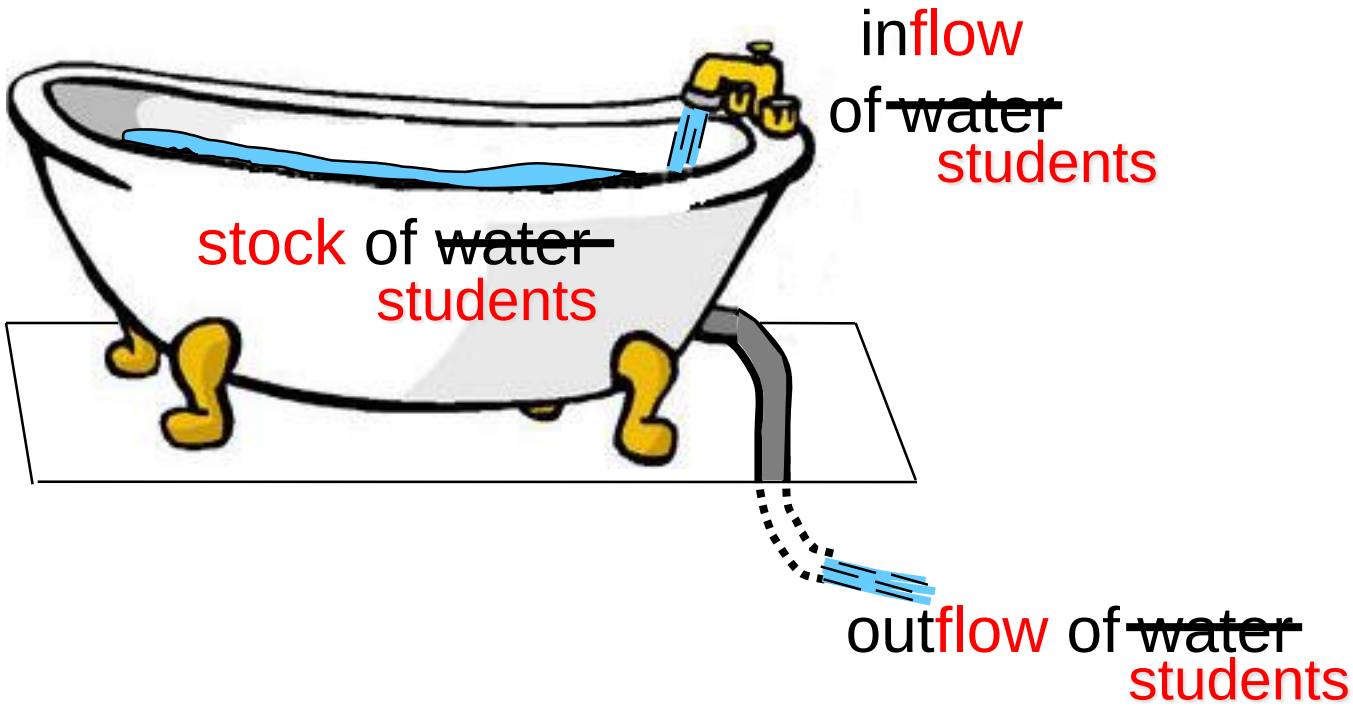


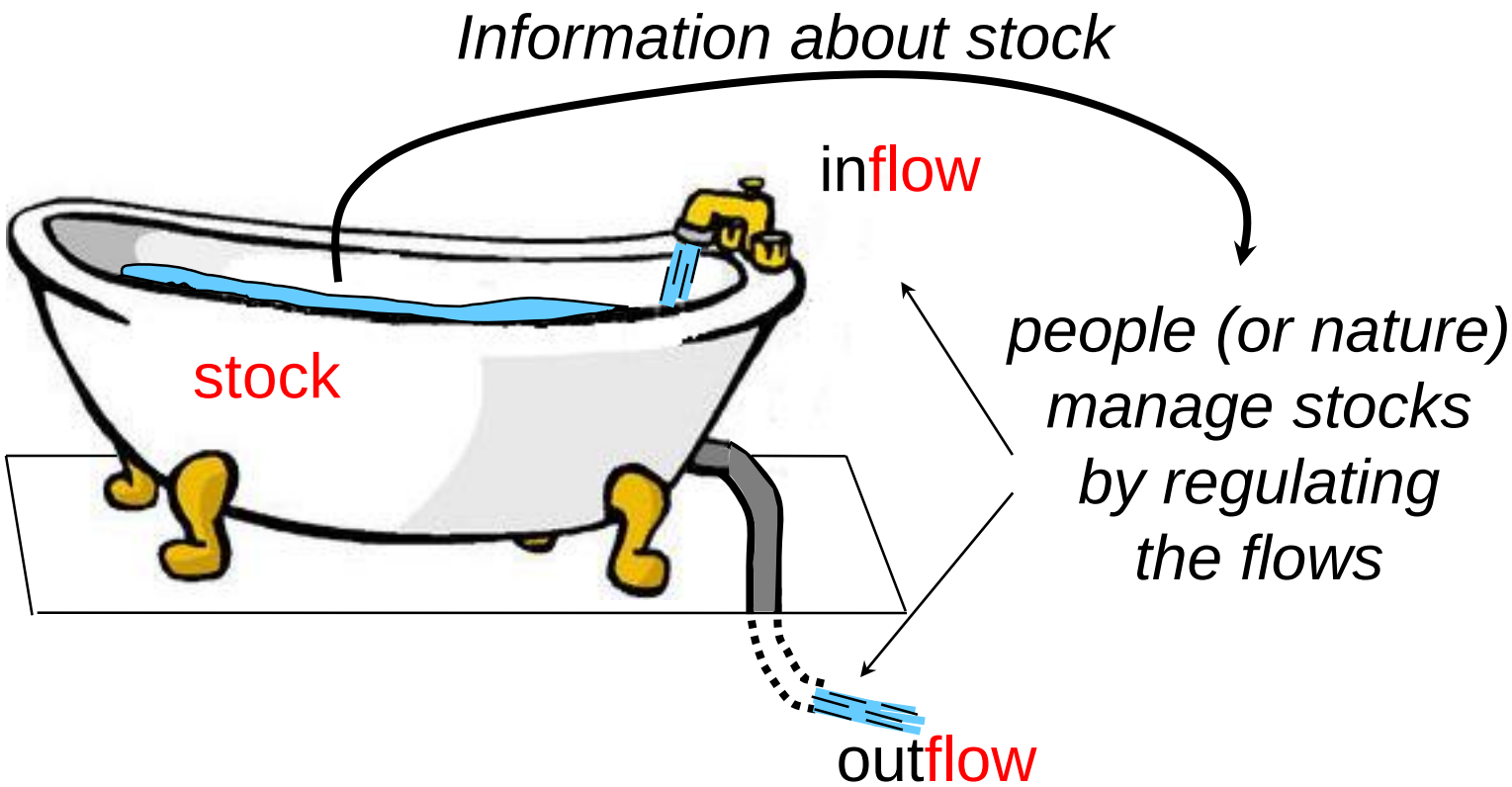
System Dynamics

A simulation modeling approach to the *study* and *management* of dynamic problems in socio-economic systems.

Key Concepts:

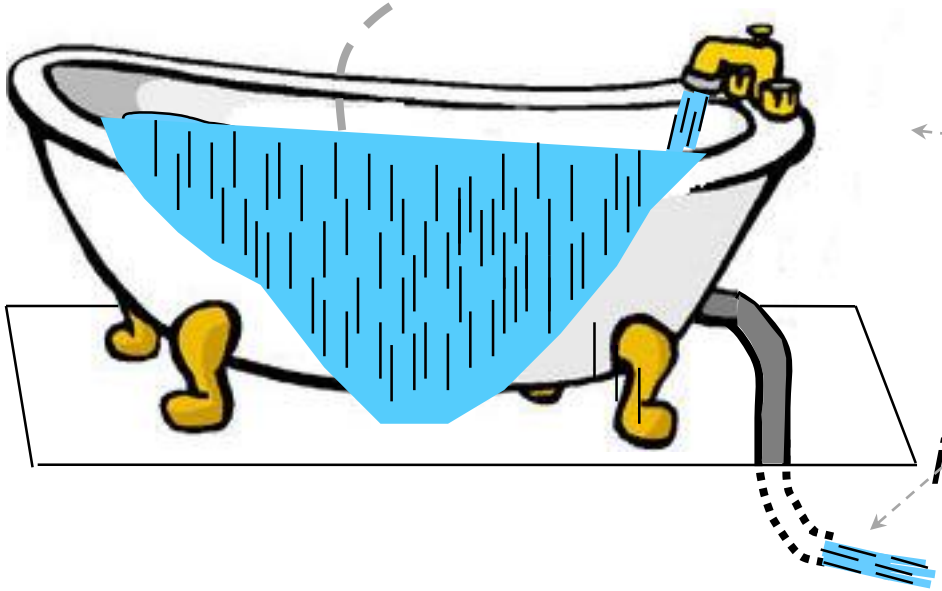
- Structure: stocks, flows, and feedback loops
- Behavior: (1) levels of the stocks and (2) rates of the flows

Feedback Thinking



Structure of a system: stocks, flows, and feedback loops
Behavior of a system: the levels of the stocks and the rates of the flows.

Need for a Policy Model



Sometimes flows are poorly regulated, causing stocks to be mismanaged.

?

?

Why? Feedback information is ignored or misunderstood.

If the current structure is creating problematic behavior, new policies are needed.
Policy modeling task: modify the feedback structure to improve regulation of the flows.

System Dynamics

A simulation modeling approach to the *study* and *management* of dynamic problems in socio-economic systems.

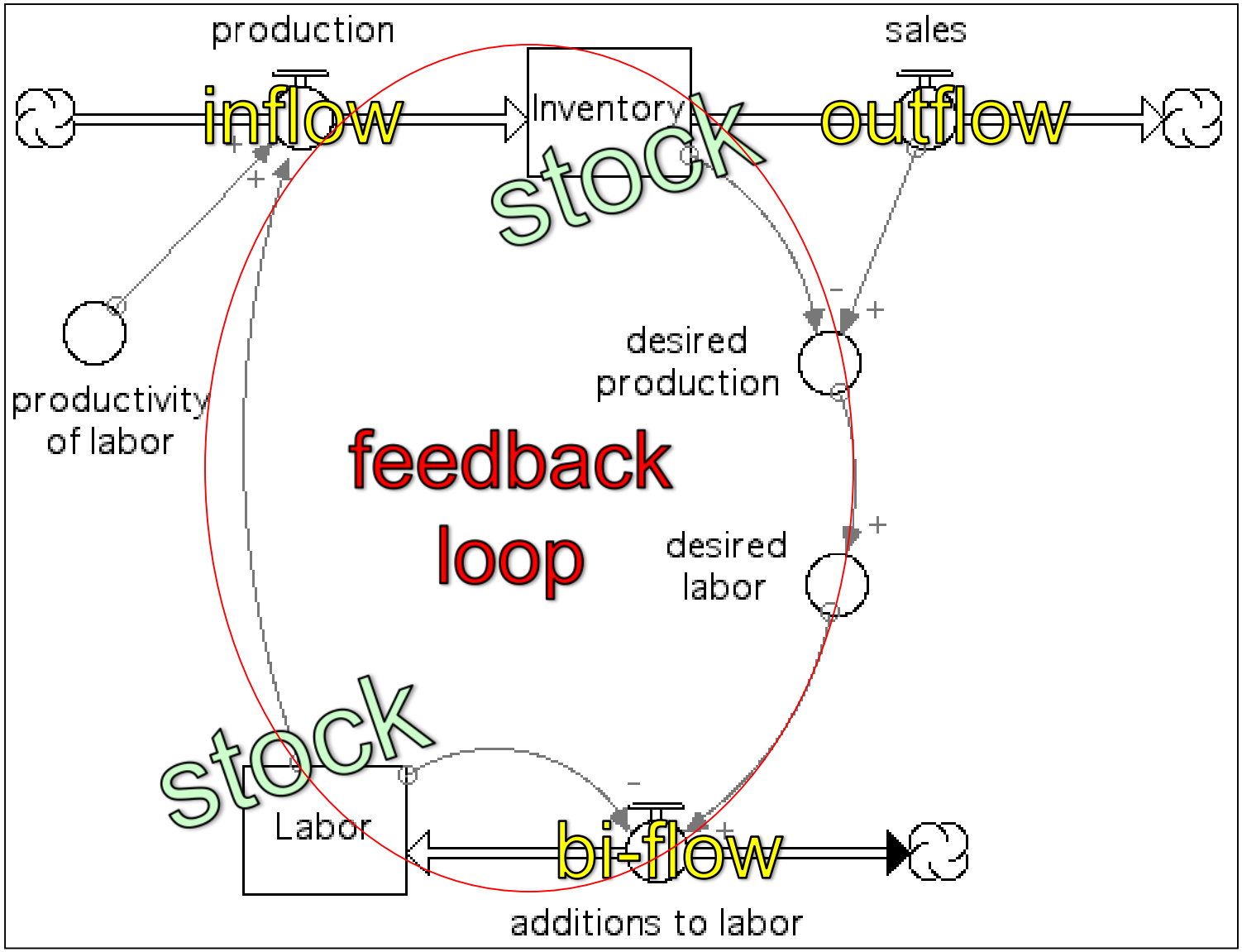
Key Concepts:
- Structure: stocks, flows, and feedback loops
- Behavior: (1) levels of the stocks and (2) rates of the flows

Key Principles:
- The dynamic behavior of a system depends on the structure of that system.
- To understand dynamic behavior, build a model of the underlying structure.
- To alleviate problematic dynamic behavior, re-design the underlying structure.

explanatory model

policy model

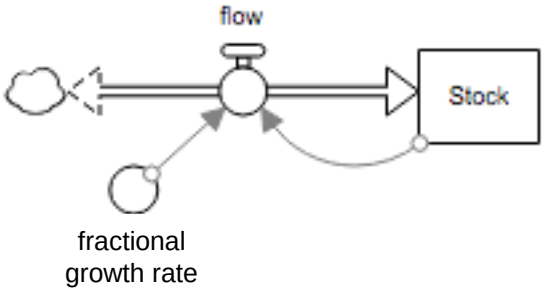
Stocks, Flows, Feedback



Some Common Flow Equations

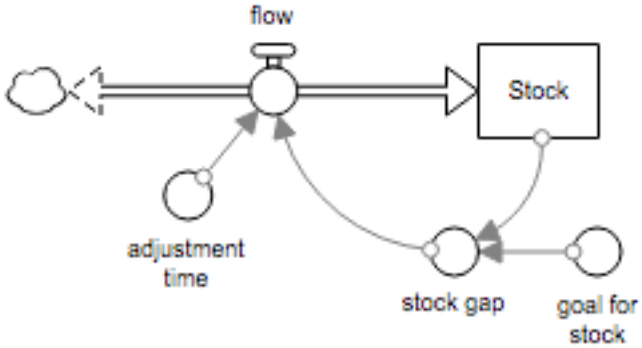
1. Fractional growth rate

Flow = stock * fractional growth rate



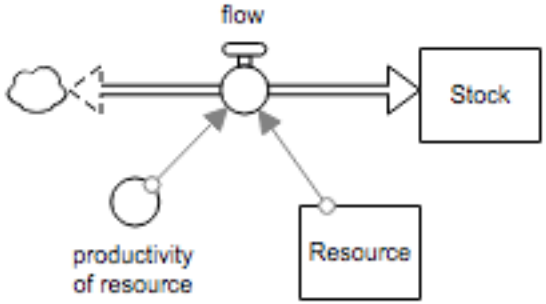
2. Goal-Seeking

Flow = stock gap / adjustment time



3. Production function

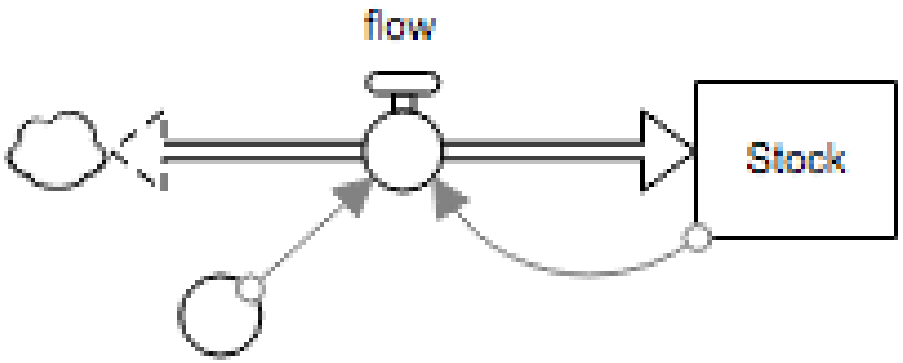
Flow = resource * productivity of resource



Fractional Growth Rate

1. Fractional growth rate

Flow = stock * fractional growth rate

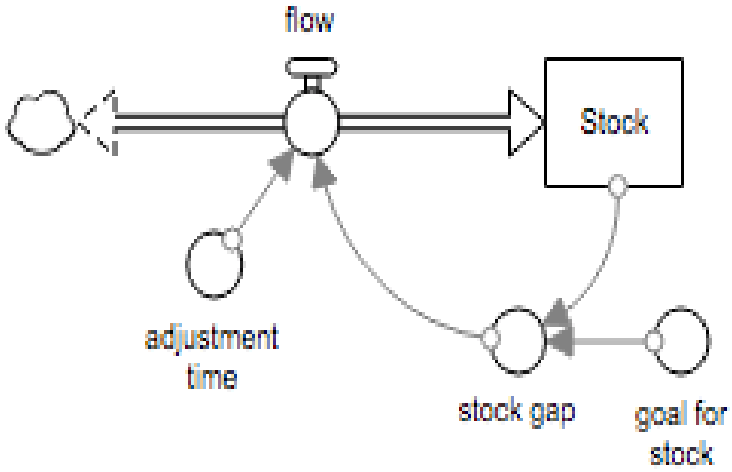


fractional
growth rate

Explicit Goal-Seeking

2. Goal-Seeking

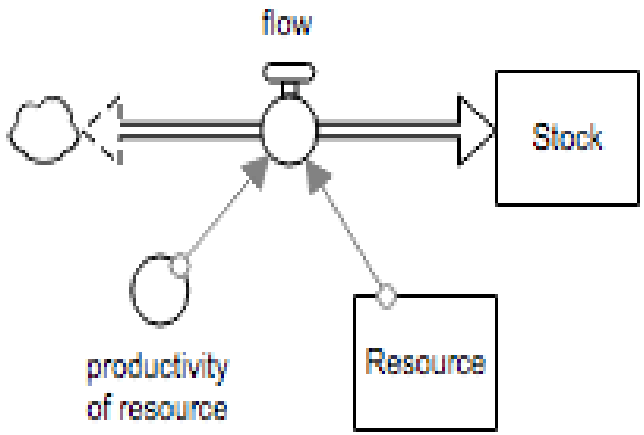
Flow = stock gap / adjustment time



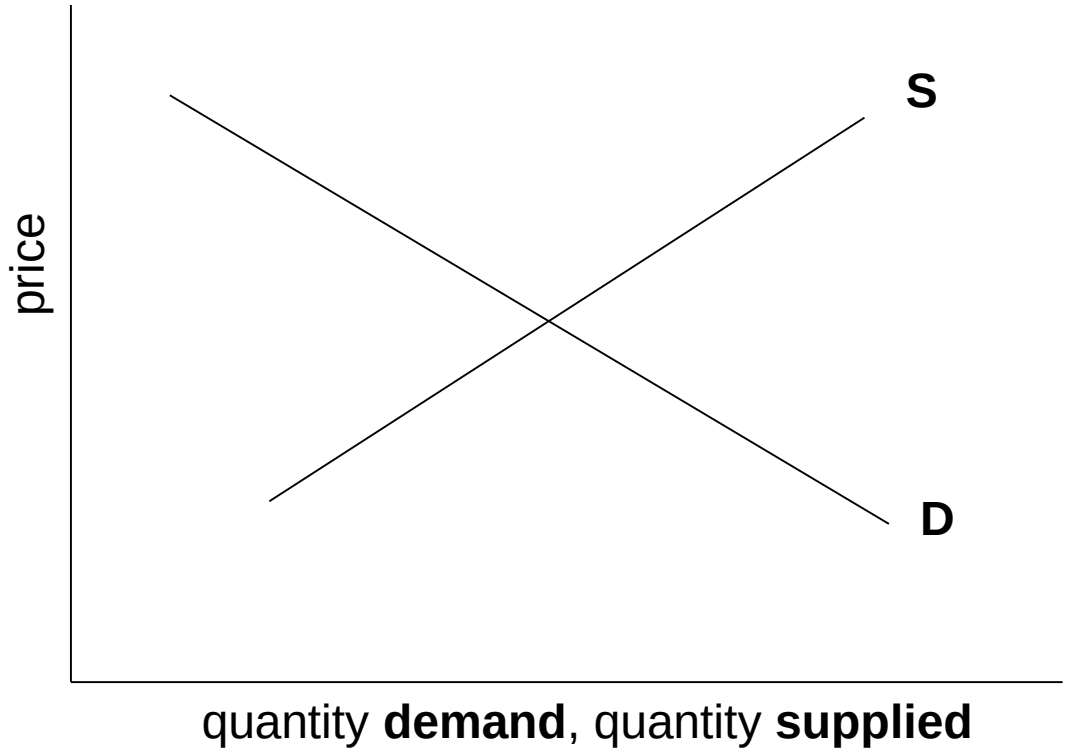
Production Function

3. Production function

Flow = resource * productivity of resource



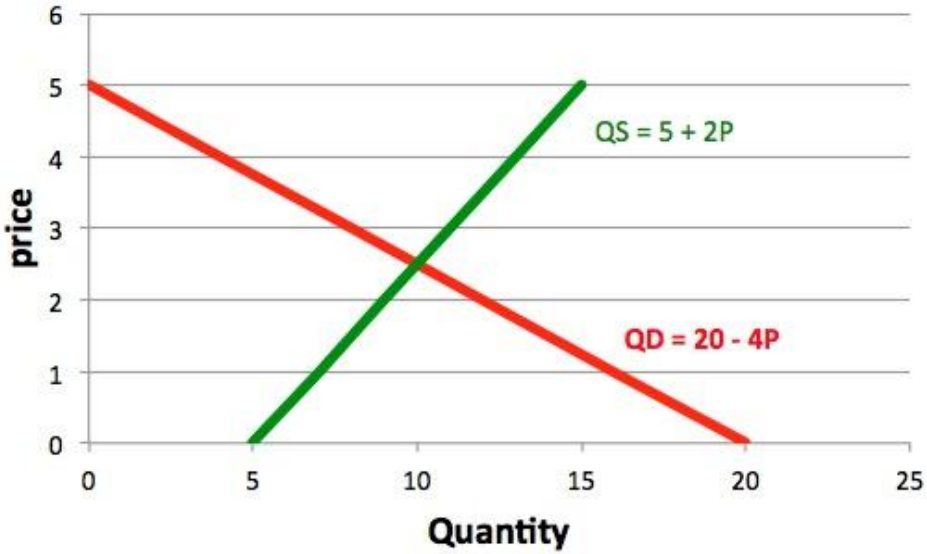
Static Supply-Demand Model



Conversion: static model to dynamic model

ED* 2.1, *Introduction to Economic Dynamics (Shone)

Adding time (t)
to the static model:



QD(t) = 20 - 4*P(t)
QS(t) = 5 + 2*P(t)

Equilibrium conditions: p = 2.5 and q* = 10*

Quantity Traded (t) = QT(t) = MIN(QD(t) , QS(t))

P(t+1) = P(t) + a*(QD(t) - QS(t)) a = 0.05

Model 2-1: dynamic supply-demand model (spreadsheet)

Model 2.1 (spreadsheet)

From section 2.1 of Shone's *Introduction to Economic Dynamics*

QD(t) = 20 - 4*P(t)

QS(t) = 5 + 2*P(t)

P(t+1) = P(t) + a*(QD(t) - QS(t))

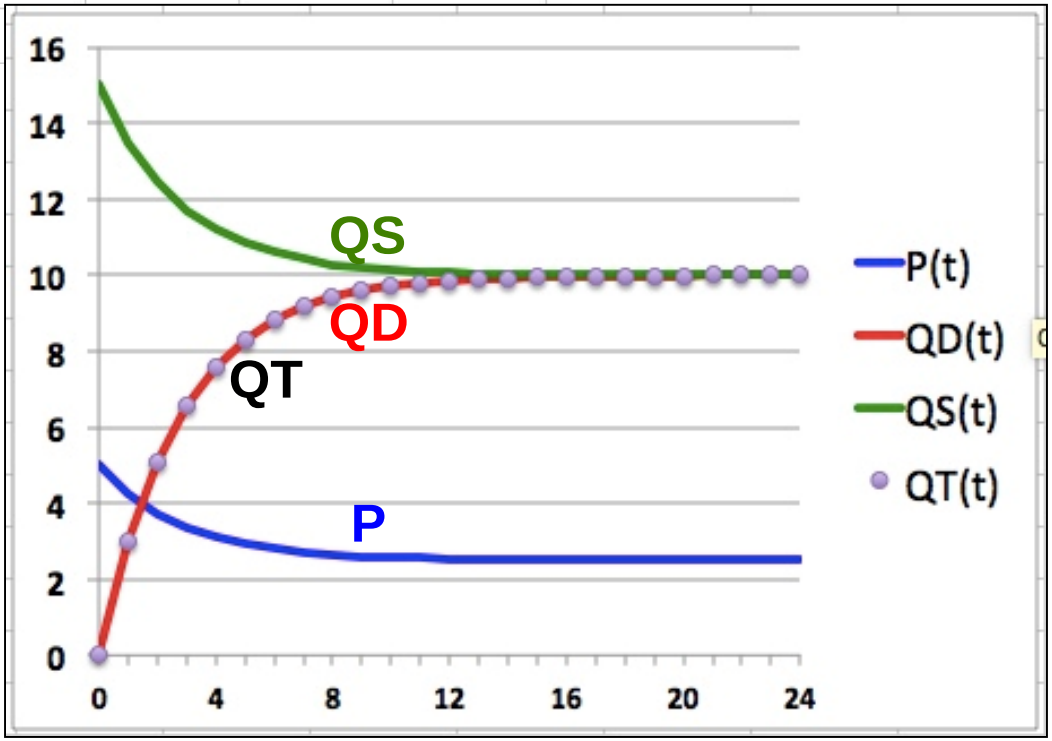
QT(t) = MIN(QD(t) , QS(t))

p* = 2.5

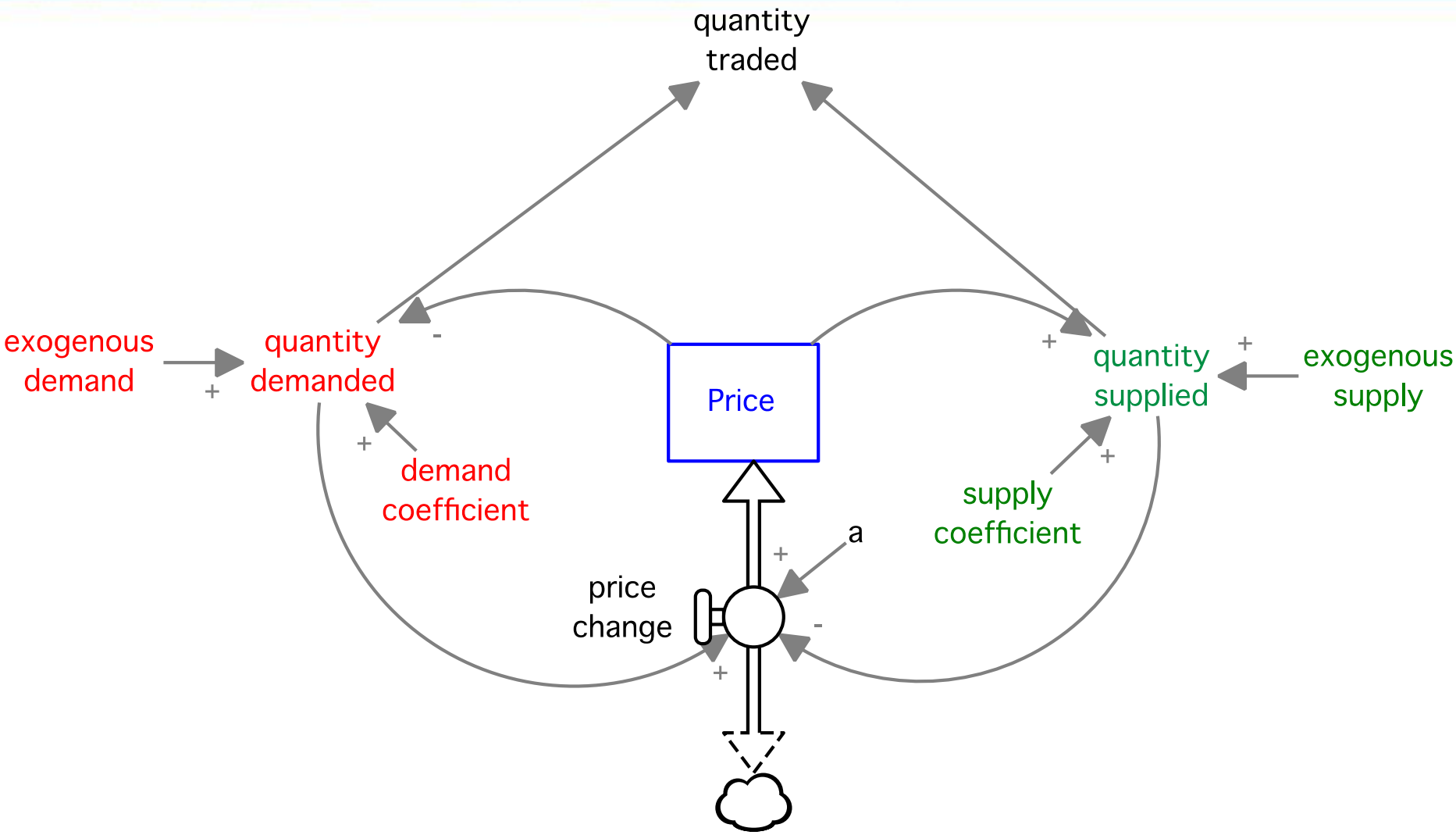
q* = 10

a = 0.05

t	P(t)	QD(t)	QS(t)	QT(t)
0	5.00	0.0	15.0	0.0
1	4.25	3.0	13.5	3.0
2	3.73	5.1	12.5	5.1
3	3.36	6.6	11.7	6.6
4	3.10	7.6	11.2	7.6
5	2.92	8.3	10.8	8.3
6	2.79	8.8	10.6	8.8
7	2.71	9.2	10.4	9.2
8	2.64	9.4	10.3	9.4
9	2.60	9.6	10.2	9.6
10	2.57	9.7	10.1	9.7
11	2.55	9.8	10.1	9.8
12	2.53	9.9	10.1	9.9
13	2.52	9.9	10.0	9.9
14	2.52	9.9	10.0	9.9
15	2.51	10.0	10.0	10.0
16	2.51	10.0	10.0	10.0
17	2.51	10.0	10.0	10.0
18	2.50	10.0	10.0	10.0



Model 2-1a: dynamic supply-demand model (system dynamics)



https://exchange.iseesystems.com/public/david-wheat/model-2.1a/index.html#page1

I. David Wheat

Professor of System Dynamics, University of Bergen, Norway
Adjunct Professor of Economics, Virginia Western Community College, U.S.A.
Professor, Monetary Policy, ISM University of Management & Economics, Lithuania
Professor, Economic Dynamics, National University of Kyiv-Mohyla Academy, Ukraine

Professor Wheat studies economic systems. His research specialty is simulation modeling of European economies, including Ukraine, Lithuania, Latvia, and the Euro Area.

He teaches monetary policy and economic dynamics to graduate students in Lithuania and Ukraine. He also teaches macroeconomics to undergraduates in the United States. In Norway, after teaching the system dynamics modeling process for many years, he continues to offer courses in macroeconomic dynamics and policy design & implementation. His projects include collaboration with Ukrainian economists to build dynamic modeling capacity at national universities in Kyiv and Lviv, creation of a system dynamics version of the central bank's monetary policy model and building an economic development policy model for Ukrainian government ministries. He also worked with economists at Lithuania's central bank to develop a multi-industry system dynamics model of price dynamics in Europe.

For more than twenty years, his system dynamics-based *MacroLab* model has been used by macroeconomics students in the United States. That model is available online, and students can use it without special software. He is currently writing a textbook to supplement student use of *MacroLab*. His latest economics journal article is *Teaching Endogenous Money with Systems Thinking and Simulation Tools*, and the most recent conference paper was *MacroLab20: A Framework for Comparative Macroeconomics* (with M. Oliskevych and A. Novik). He is co-editor of *Feedback Dynamics*, published by Springer in July 2021, including a chapter co-authored with Oliskevych and Novik: 'Get Started with Macro Modeling.'

Wheat is past-president of the economics chapter of the International System Dynamics Society. He served as Associate Editor of the *System Dynamics Review* and on the Advisory Board of the *International Journal of Pluralism and Economics Education*. He has given more than thirty international guest lectures. For three decades, he was president of Wheat Resources Inc, a consulting firm serving business and government clients. His current firm, Praktika LLC, specializes in coaching others to build useful models (https://www.usefulmodels.net). He received his PhD at the University of Bergen, his master's degree in public policy at Harvard University, and his bachelor's degree in government and mathematics at Texas Tech University. During the 1970s, he served at the White House as staff assistant to the President of the United States.