Economic Dynamics

David Wheat, PhD, MPP

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Lecture 1: Introduction to Dynamic Modeling

September 17, 2020

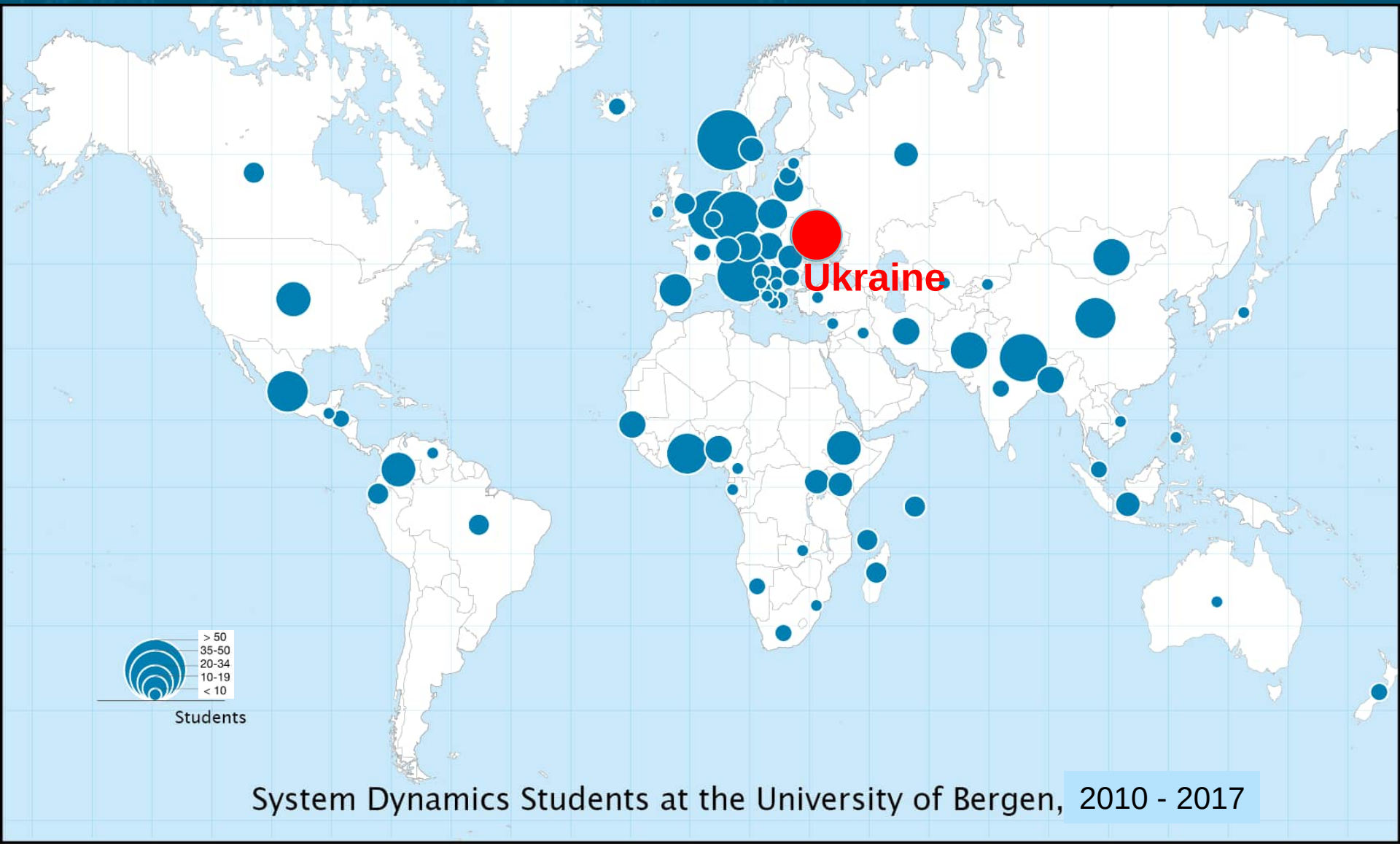
Professor
ISM University, Lithuania

Professor
Virginia Western College, USA

UNIVERSITETET I BERGEN

System Dynamics Group

Ukrainian SD Students in Bergen



Learning Economics with Dynamic Modeling

Project (2012-2021) funded by Norwegian Centre for International Cooperation in Education

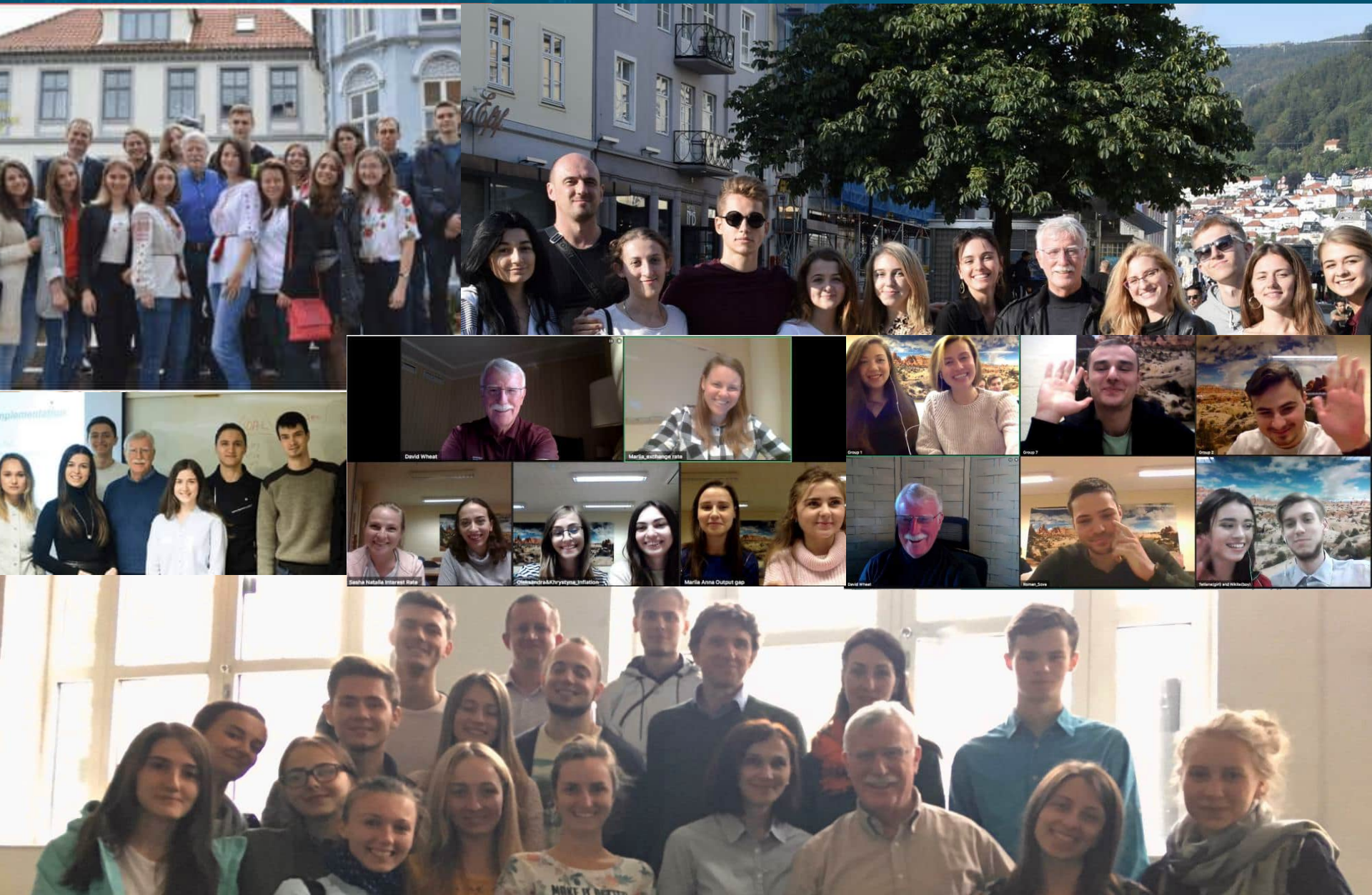
Goal: Develop Dynamic Modeling Capacity at NaUKMA (finance dept.) & LNU (mathematical economics dept.)

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

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 built with spreadsheets and system dynamics. Statistical correlational models are also compared with system dynamics causal models.

Course Prerequisites: None

Course Objectives

- Distinguish between static and dynamic economic models;
- Translate difference equation models into spreadsheet-based dynamic models;
- Compare the spreadsheet and system dynamics approaches to dynamic modeling;
- Compare correlational models and causal models;
- Develop basic skills in system dynamics modeling.

Instructional Methods

This is an online course, using Zoom. Normally, there would be a few face-to-face lectures, but those are prevented this year by the pandemic. Most lectures will be 'live' but some may be video-recorded.

All lectures are supplemented by reading assignments, slideshow tutorials, discussion board tasks, and simulation exercises.

Online computer lab sessions conducted by the teaching assistant provide opportunities to improve skills introduced during the lectures and assignments. Lab sesssions and assignment deadlines will be decided by the teaching assistants.

Materials

READING

Shone*: An Introduction to Economic Dynamics (*Shone 2003)
Sterman: *Business Dynamics* (2000)

Journal articles & chapters from other books will also be assigned

SOFTWARE

Spreadsheet software (e.g., Microsoft *Excel)*

System Dynamics simulation software

- *Stella Architect,* version 2.01
- 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 17	**Introduction to Dynamic Modeling**
Sep 24	Simple Keynesian Dynamics
Oct 1	IS Dynamics
Oct 8	IS-LM Dynamics
Oct 15	Alternative Models (IS-PC-MR & others)
Oct 16-28	—- autumn break—-
Oct 29	Dynamics of Economic Instability
Nov 5	Dynamics of Economic Growth
Nov 12	Economic Policy Dynamics
Nov 19	Open Economy Dynamics
Dec 7	Submit Final Exam Project

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. Read: ***Shone*** pp. 27-30, 48-58; skim quickly **Sterman** pp. 300-314

3. Study Shone's spreadhseet model in Fig 2.1; then study SD version online

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

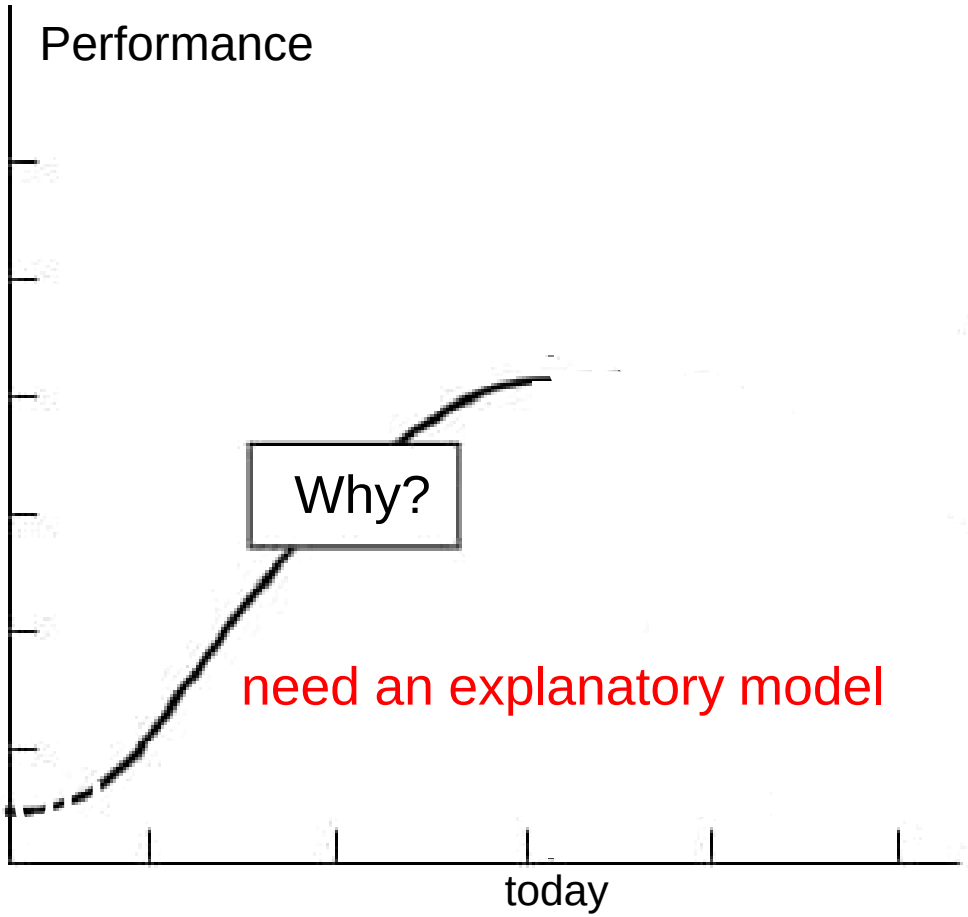
4. Build spreadsheet model in Shone, Fig 3.5.

Send all 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 200921

zip all files before emailing

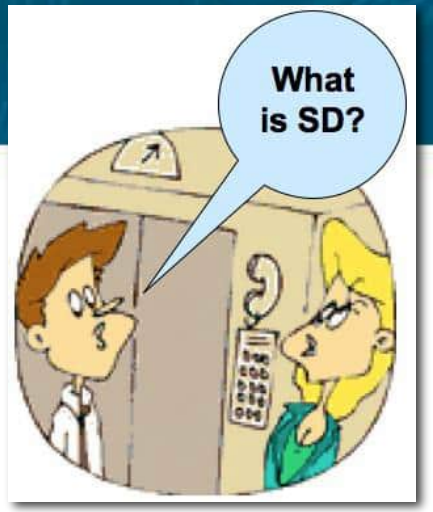
What questions does SD seek to answer?



need a policy model

Warren, K. (1999). The Dynamics of Strategy, *Business Strategy Review*

System Dynamics

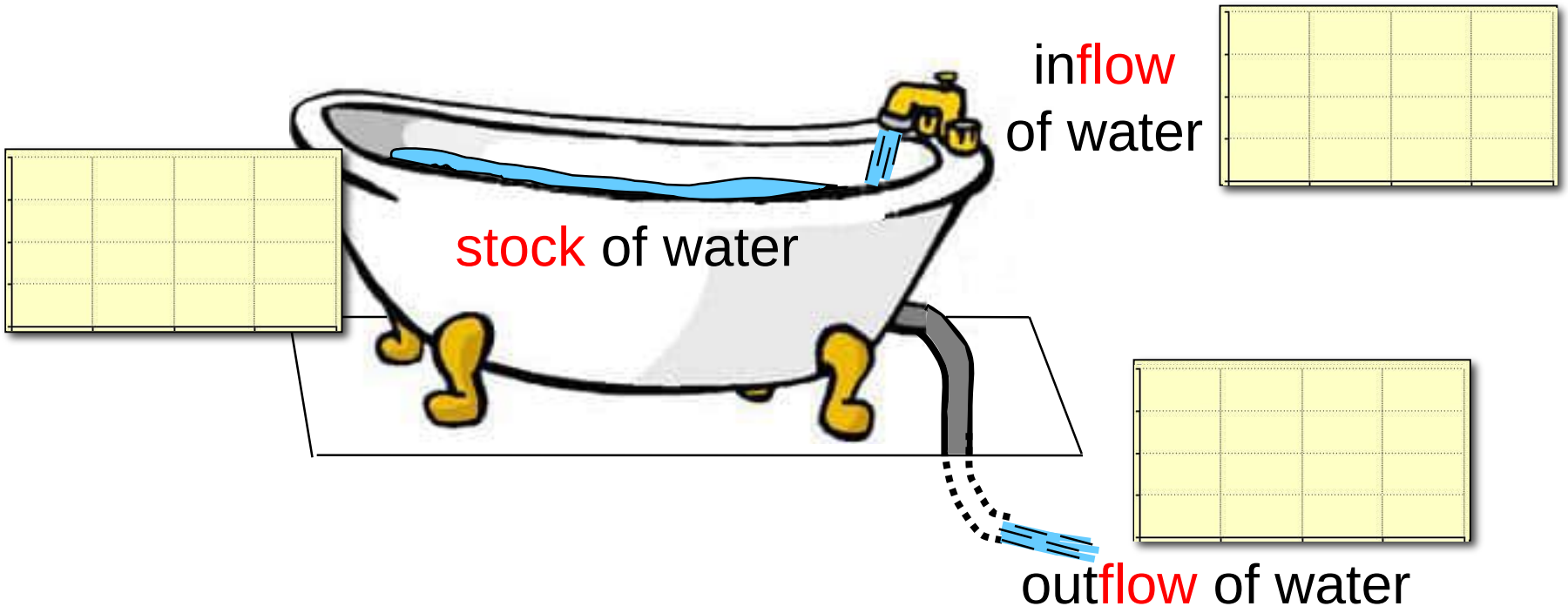


A simulation modeling approach
to the *study* and *management* of
dynamic problems in socio-economic systems.

Key Concepts:

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

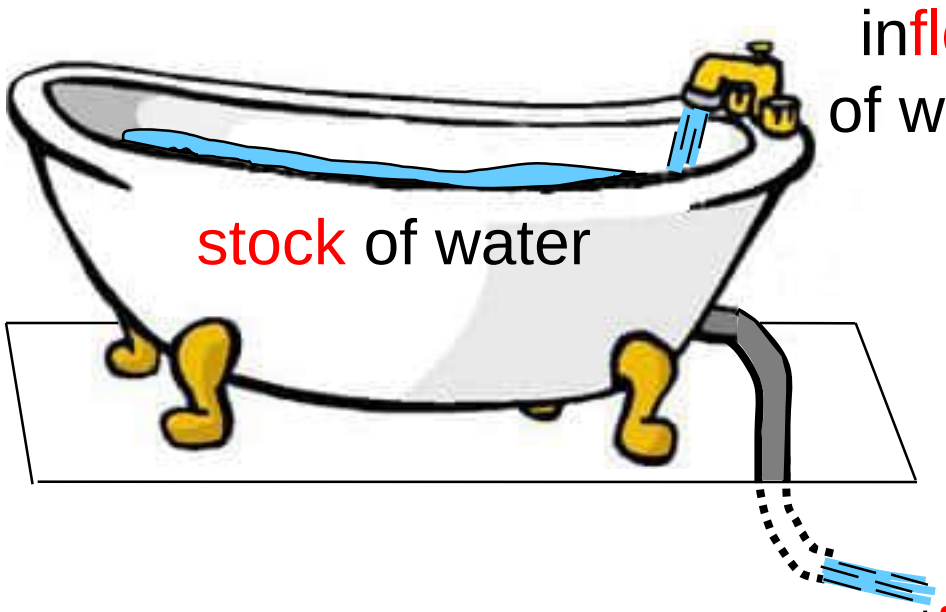
Structure and Behavior



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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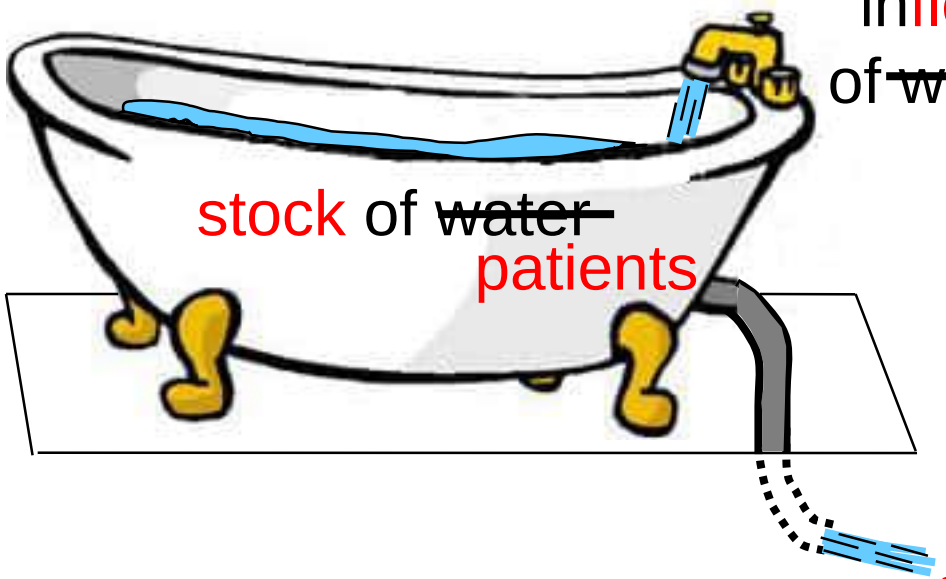

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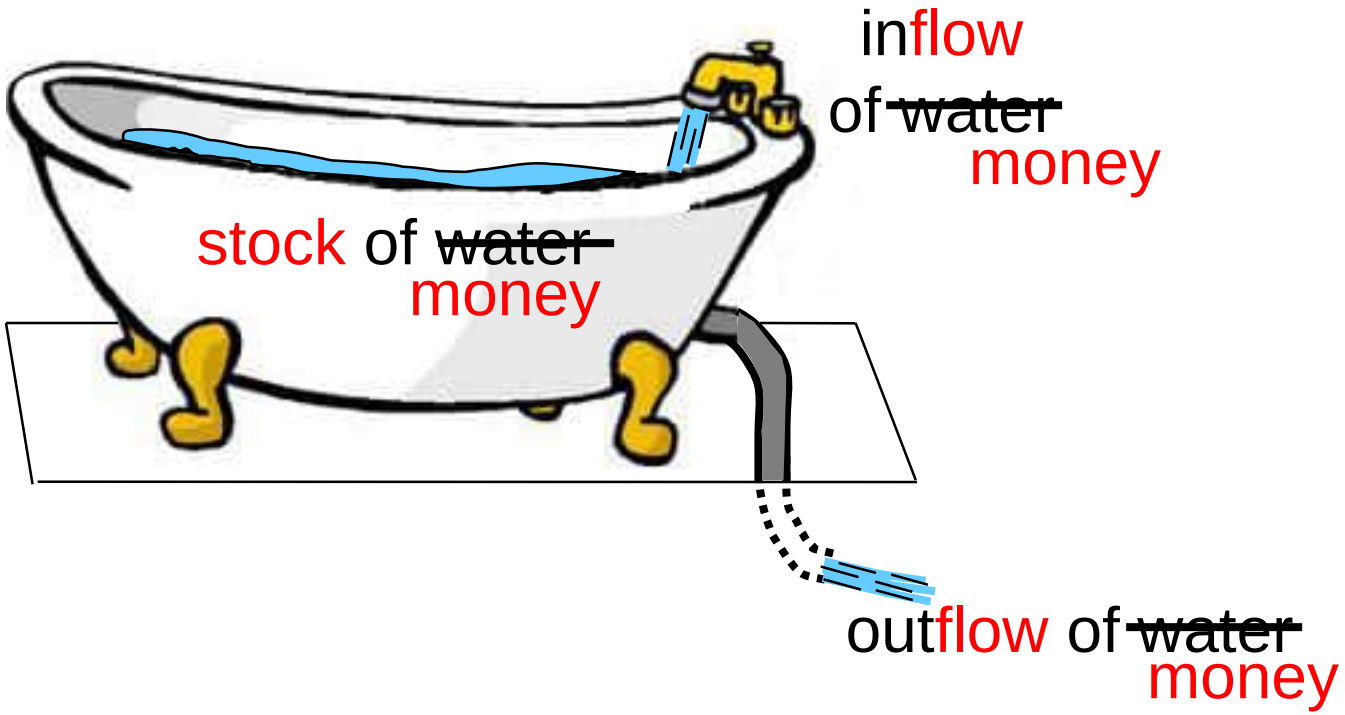

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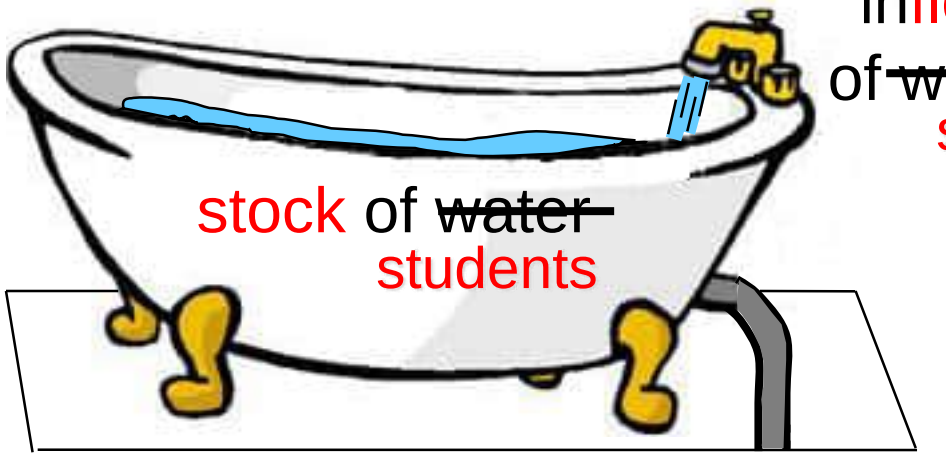
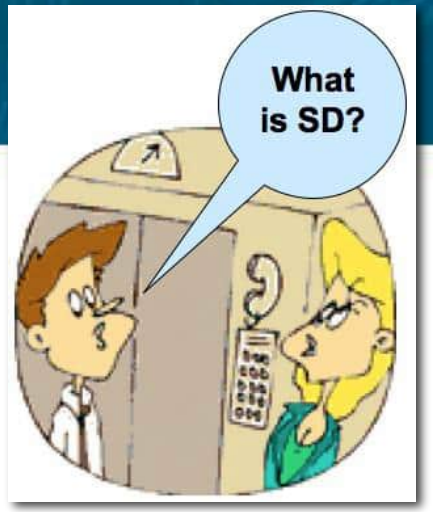


System Dynamics



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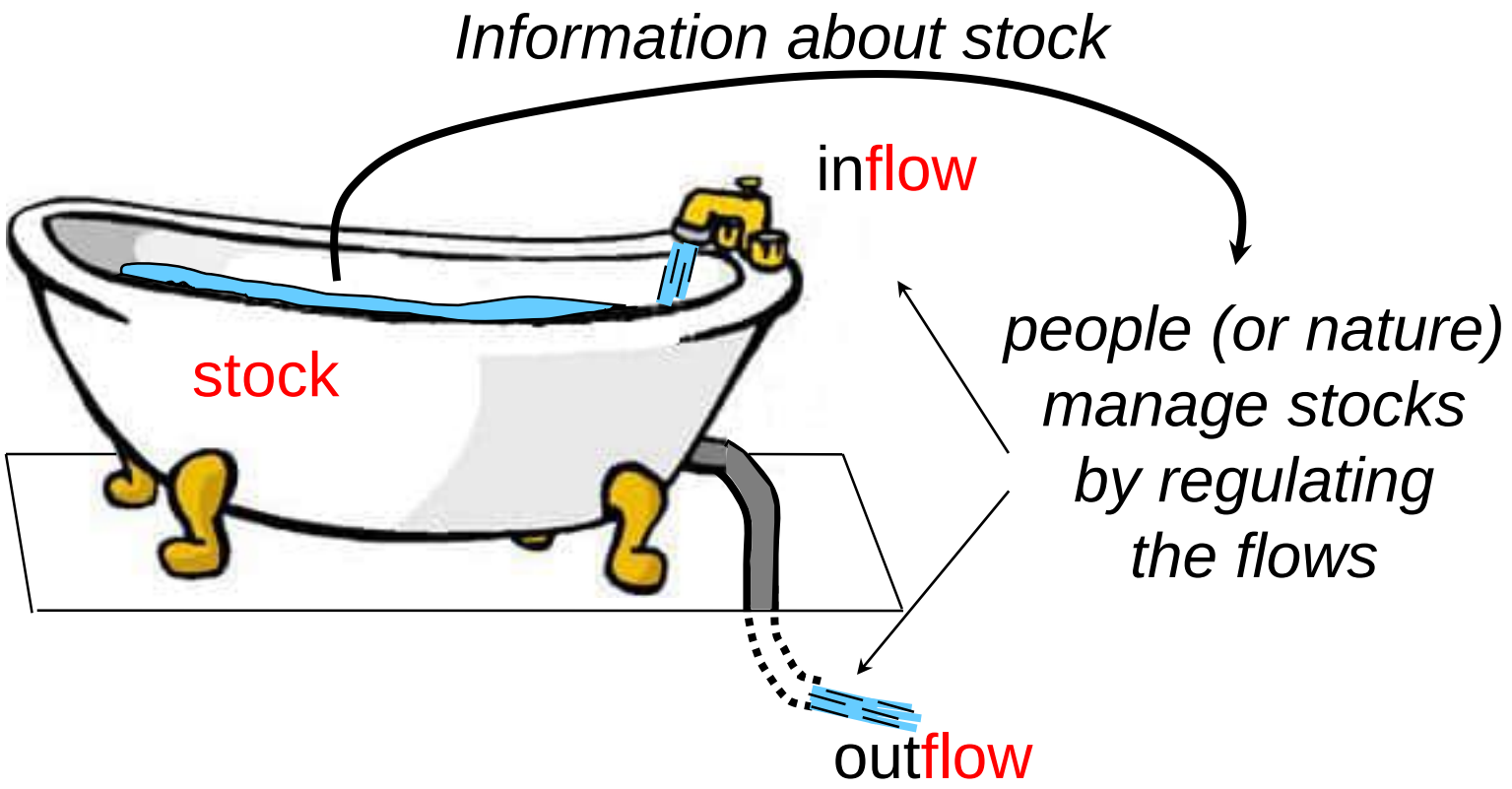
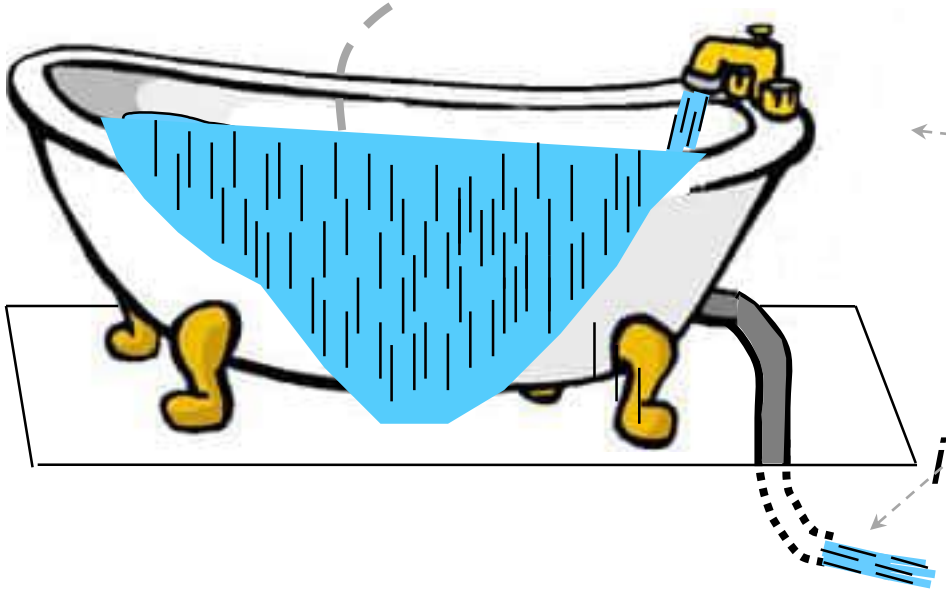
Feedback Thinking



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

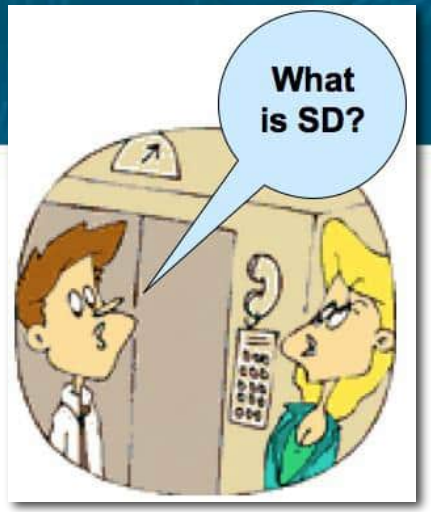
Sometimes flows are poorly regulated, causing stocks to be mismanaged.



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



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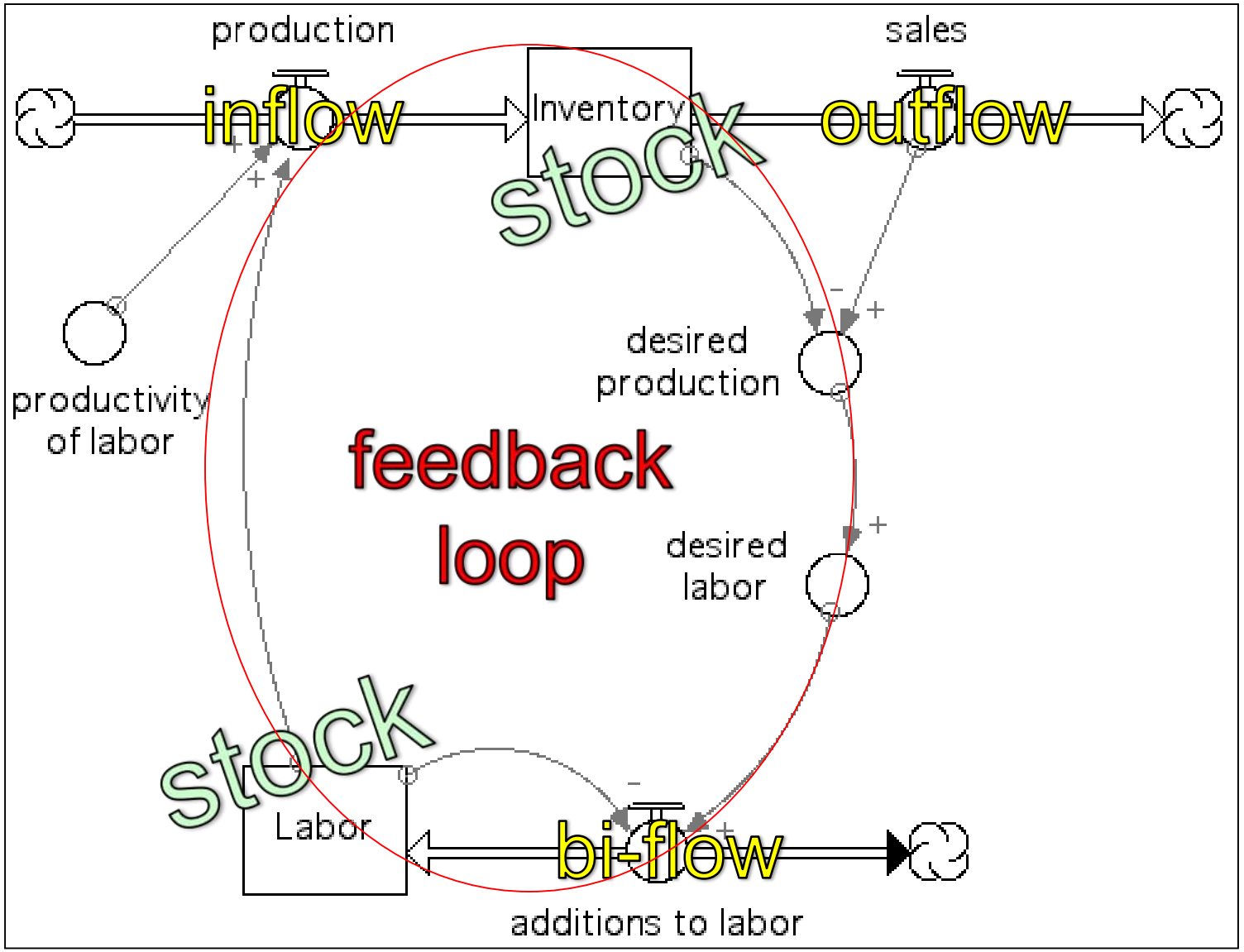
Key Principles:
- The dynamic behavior of a system depends on the structure of that system.
- To understand dynamic behavior, build a model of the underlying structure. **explanatory model**
- To alleviate problematic dynamic behavior, re-design the underlying structure. **policy model**

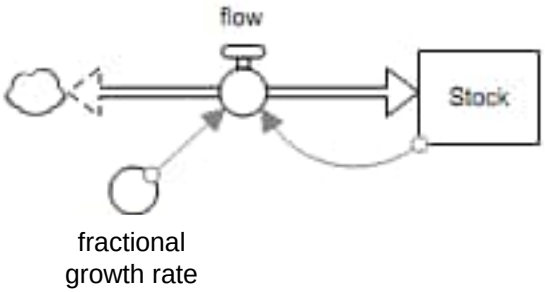
Stocks, Flows, Feedback



Some Common Flow Equations

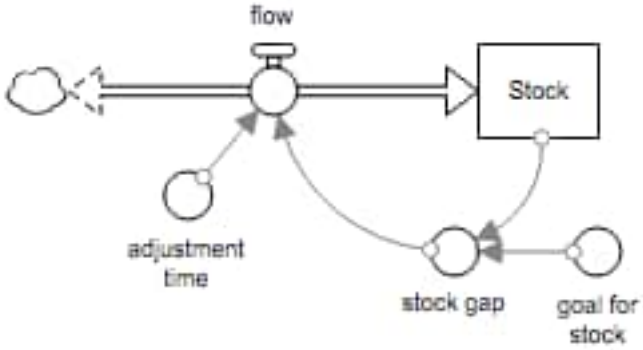
1. Fractional growth rate

Flow = stock * fractional growth rate



2. Explicit Goal-Seeking

Flow = stock gap / adjustment time



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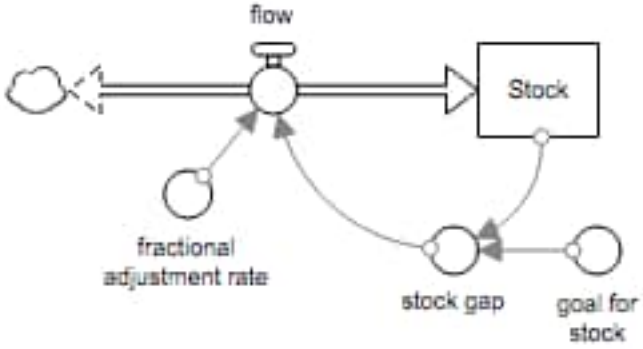
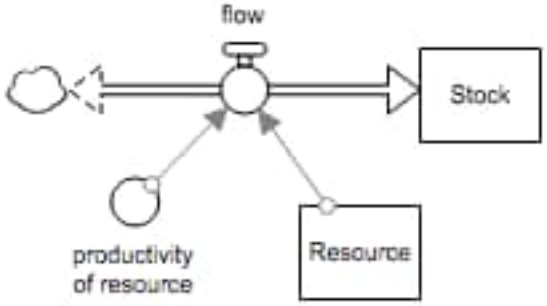


3. Production function

Flow = resource * productivity of resource



Fractional Growth Rate

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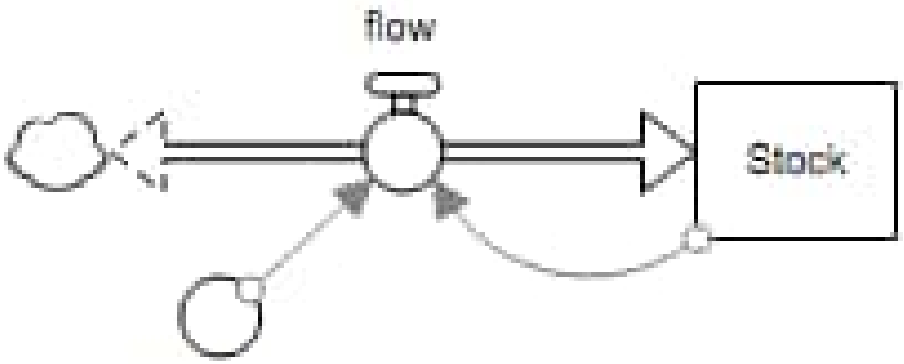

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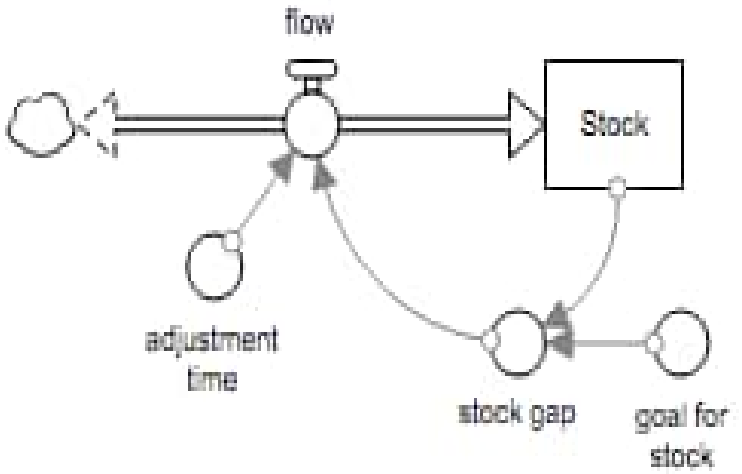

Production Function

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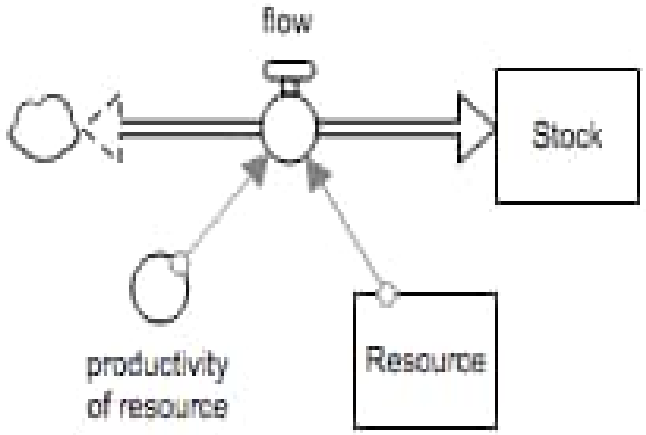


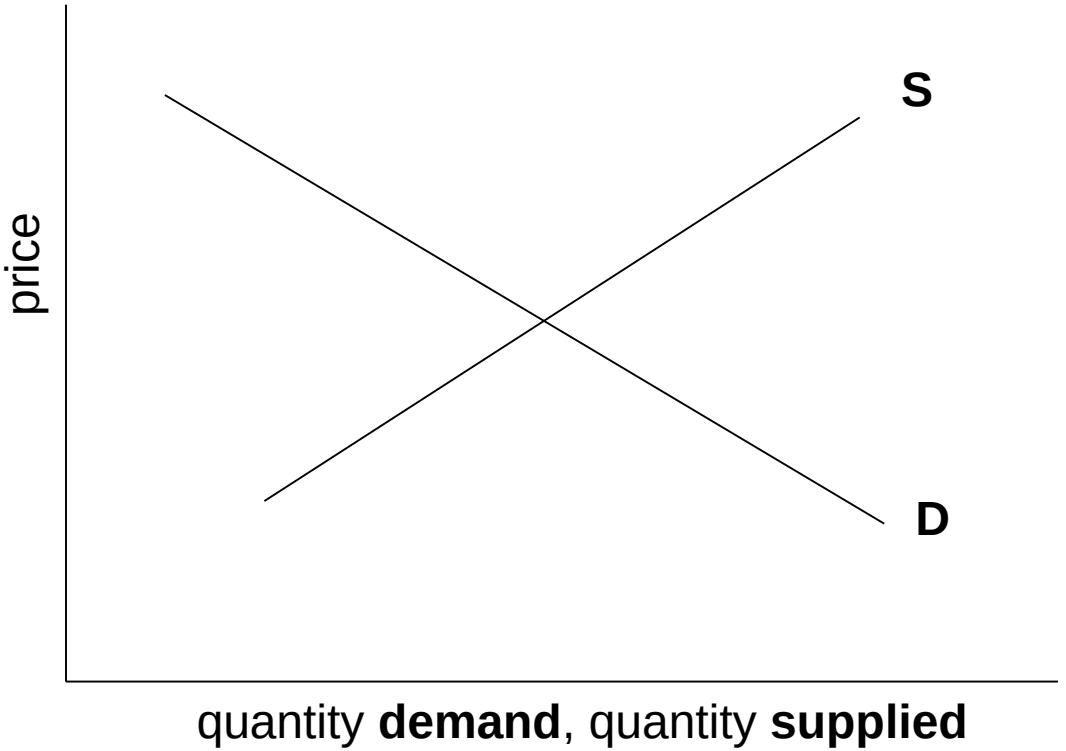
Model?

What is a model?

What economic model is most well known?

Draw that model.

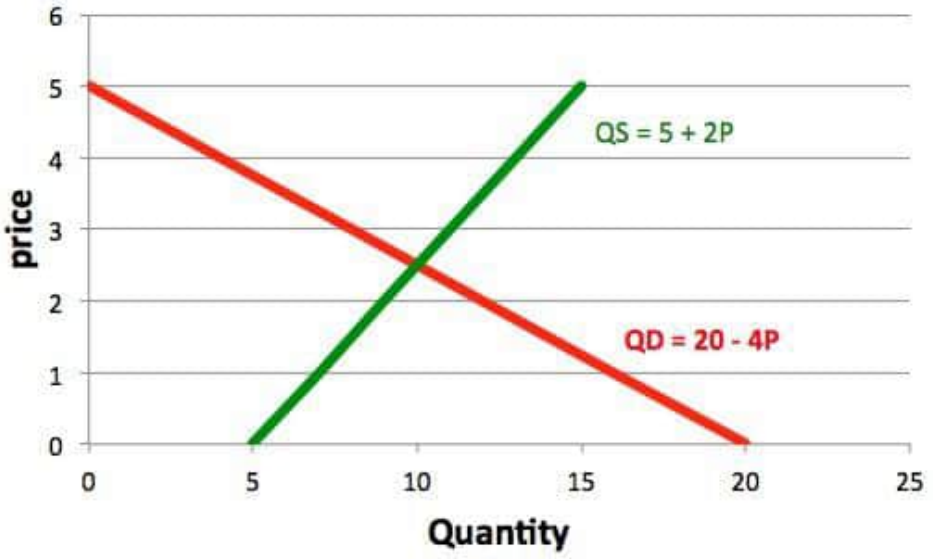
Is this a ***static*** model
or a ***dynamic*** model?



Model 2.1: static supply-demand graph

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 spreadsheet version

Model 2.1 (spreadsheet)

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

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

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

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

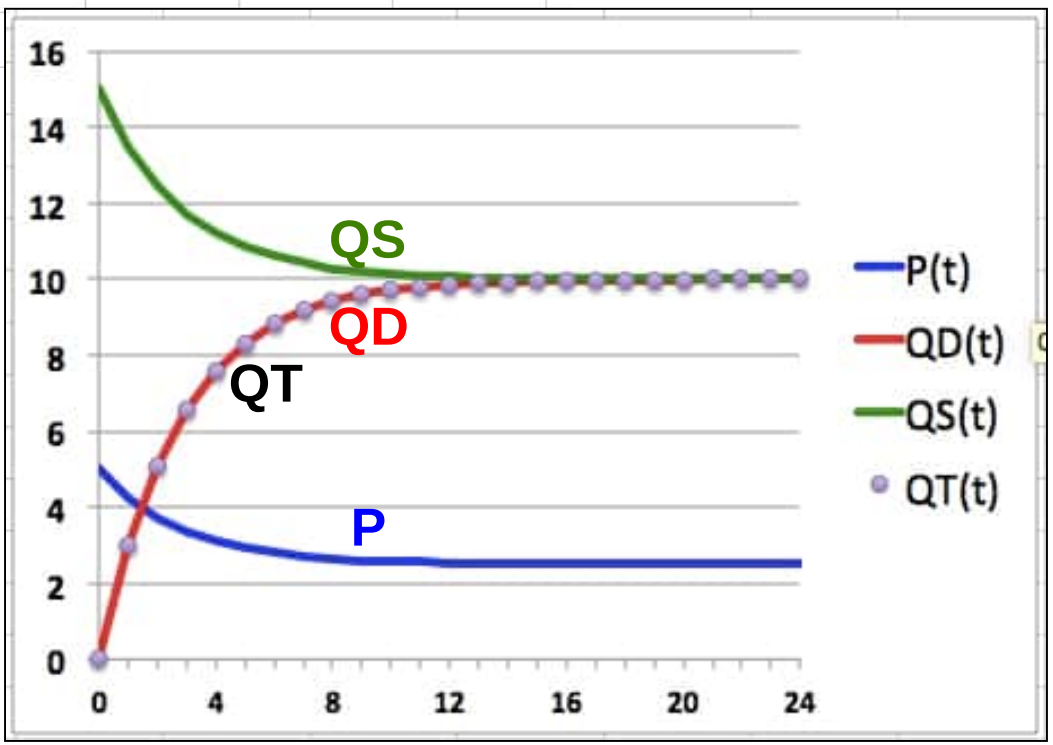
$QT(t) = MIN(QD(t), QS(t))$

$p^* = 2.5$

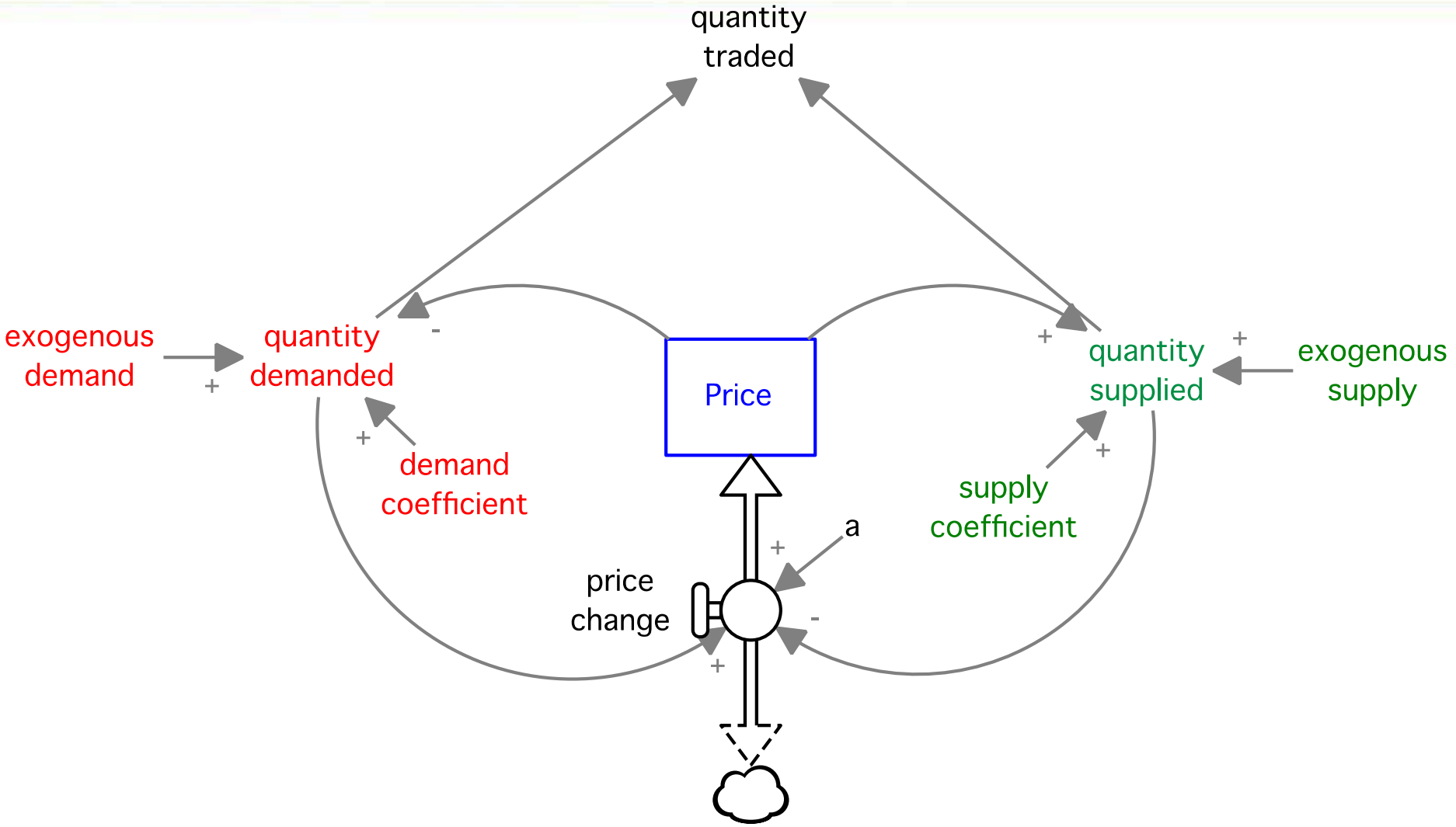
$q^* = 10$

$a = 0.05$

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 (System Dynamics version)



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

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*Use this format for file names:
LastNameFirstName YYMMDD e.g., HarrisEmmylou 200921

zip all files before emailing

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 and microeconomics 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. Current projects include collaboration with Ukrainian economists to build dynamic modeling capacity at national universities in Kyiv and Lviv, plus development of monetary policy models with economists at Ukraine's central bank. He has worked with economists at Lithuania's central bank to develop a multi-industry system dynamics model of price dynamics in Europe.

For nearly 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 *The Canonical New Keynesian Monetary Policy Model: A System Dynamics Translation* (with M. Oliskevych). He is co-editor of *Feedback Dynamics*, a book that will be published by Springer in 2020.

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. He received his PhD at the University of Bergen, his master's degree at Harvard University, and his bachelor's degree at Texas Tech University. During the 1970s, he served at the White House as staff assistant to the President of the United States.