Economic Dynamics

David Wheat, PhD, MPP

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Lecture 1: Introduction to Dynamic Modeling

September 7, 2018

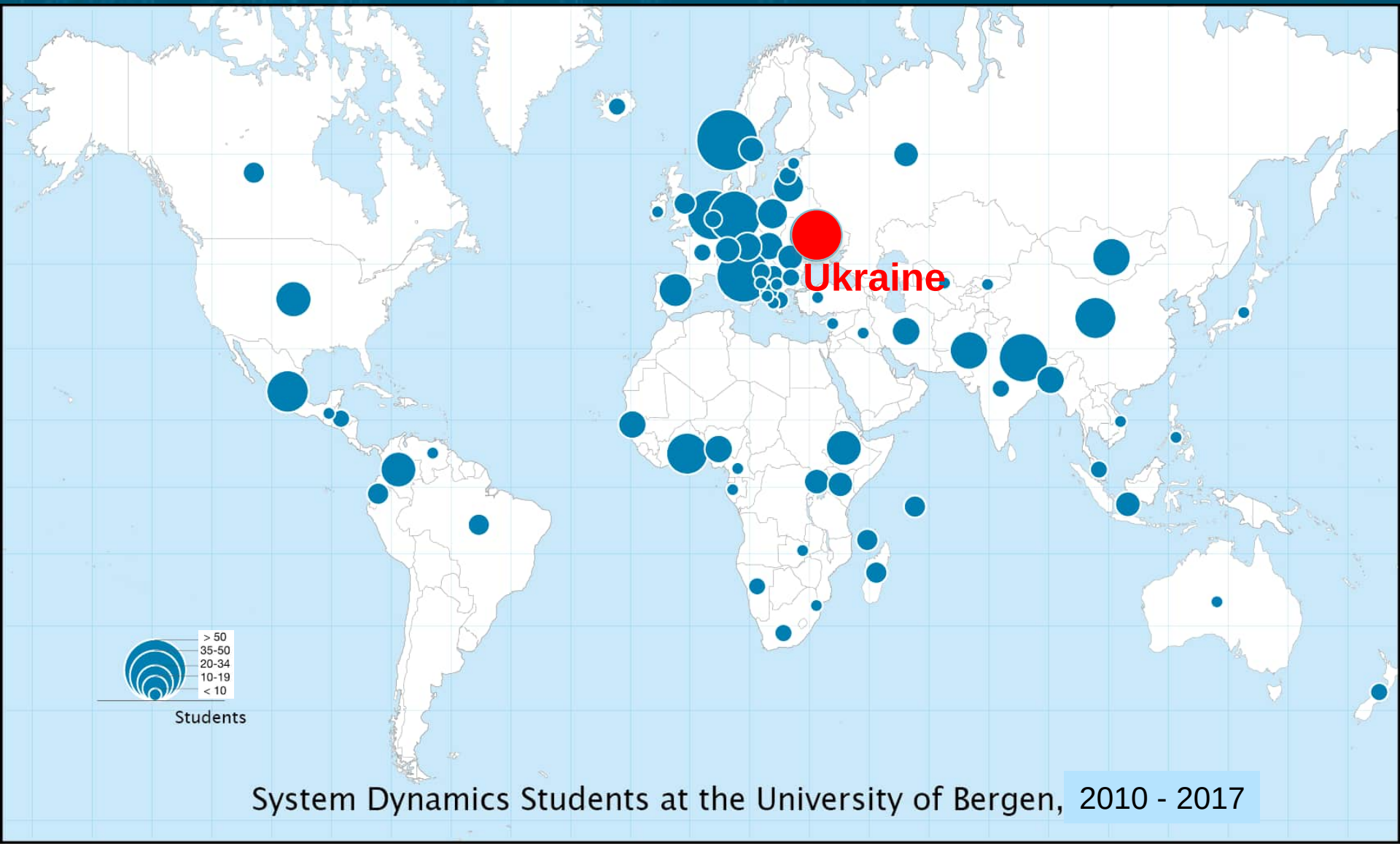
Professor
ISM University, Lithuania

Professor
Virginia Western College, USA

UNIVERSITETET I BERGEN

System Dynamics Group

Ukrainian SD Students in Bergen



Learning Economics with Dynamic Modeling

Project (2012-2019) funded by Norwegian Centre for International Cooperation in Education

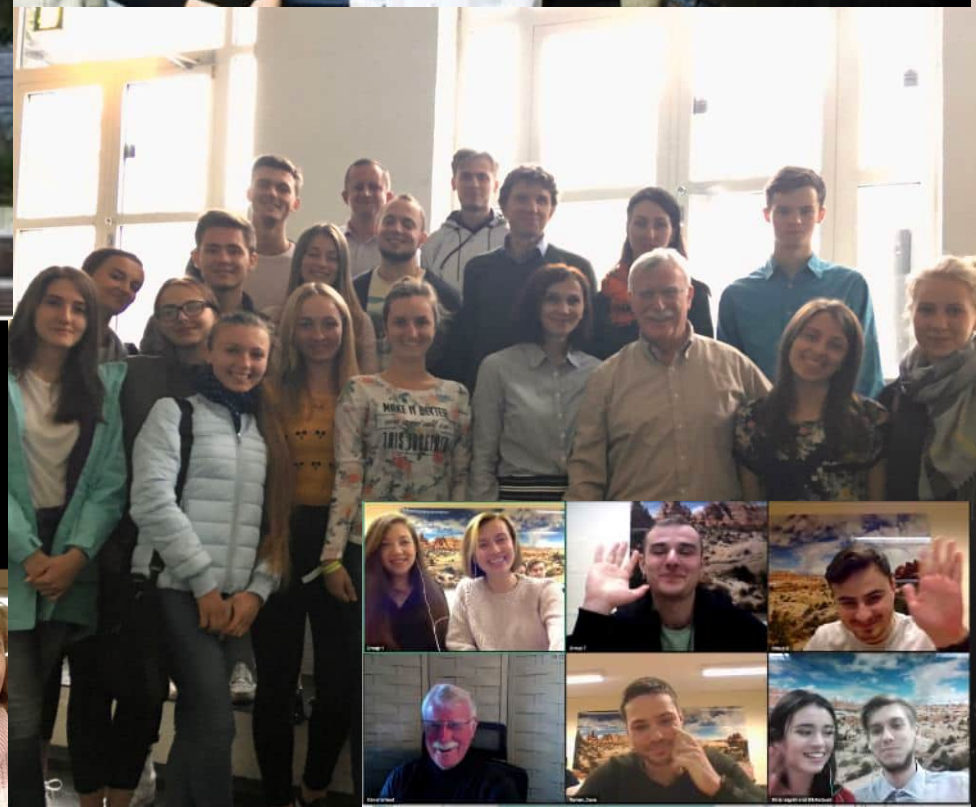
Goal: Develop Dynamic Modeling Capacity at NaUKMA (finance dept.) & LNU (mathematical economics dept.)

Strategy: Train the Trainers

Outcomes: 80+ 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

(since 2016)



Course Description

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This course introduces basic methods of modeling economic dynamics with spreadsheet software and system dynamics software.

Course Prerequisites: None

Course Objectives

To enable students to…

- Use spreadsheet software to build dynamic models,
- Use system dynamics software to build dynamic models,
- Use system dynamics as a method of scientific inquiry.

You will discover:

- the extra value added by SD-based dynamic models,
- that SD enables building more realistic & insightful dynamic models.

Instructional Methods

This is (mostly) a distance learning course.

We will communicate by email and sometimes with *Moodle*.

Some lectures are on-site and others on online (video or live)

Student work consists of
- reading assignments
- slideshow tutorials
- simulation exercises
- homework & discussion board assignments (50% of grade)
- two exams (50% of grade)

Computer lab sessions provide opportunities to improve the modeling skills introduced during the lectures and assignments.

Lectures: Thursdays, 14:30-15:20*

Sep 4 & 7	Introduction to Dynamic Modeling
Sep 13	Structure & Behavior of Dynamic Systems
Sep 20	Demand & Supply Dynamics
Sep 27	Simple Keynesian Dynamics
Oct 4	IS-LM Dynamics: Where's the Money?
Oct 11	New Keynesian Inflation Dynamics
Oct 18	guest lecture (date & time to be confirmed)
Oct 22-28	**Autumn Break**
Nov 1	**Mid-term Exam**
Nov 8	Economic Growth
Nov 15	Price Dynamics
Nov 22	Employment Dynamics
Nov 26-Dec 14	review for exam
Dec 6 & 13	review lectures at LNU (6^{th}) and NaUKMA (13^{th})
Dec 17-21	**Final Exam**

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

Materials

READING

Primary textbook

ED: *An Introduction to Economic Dynamics (*Shone 2003)

Supplementary textbooks: ***BD:*** *Business Dynamics (*Sterman 2000)

SMBD: *Strategic Modeling & Business Dynamics (*Morecroft 2007)

Journal articles to be assigned

SOFTWARE

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

System Dynamics simulation software

- *Stella Architect* (isee systems, inc.)
- individual student licenses
- each of you enrolled in the course should have an account

-- download, install, & get acquainted

Assignments for this Week

1. Practice with *Stella Architect* -- on your own

2. Read: ***ED*** (ch 2); ***BD*** (ch 4)
   "Teaching Economics as if Time Mattered" (Wheat 2009)

3. Build spreadsheet model 2.1*

4. Study SD model 2.1a onlinee

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

5. Build SD model 2.1a, based on spreadsheet model and online model*

Send all assignments to Alina (NaUKMA), Marianna (LNU), and me
alina.fin.2008@gmail.com
david.wheat@uib.no
olisk@ukr.net
*zip all files before emailing, and use this format for file names:
LastNameFirstName YYMMDD
e.g., HarrisEmmylou 180904

Model?

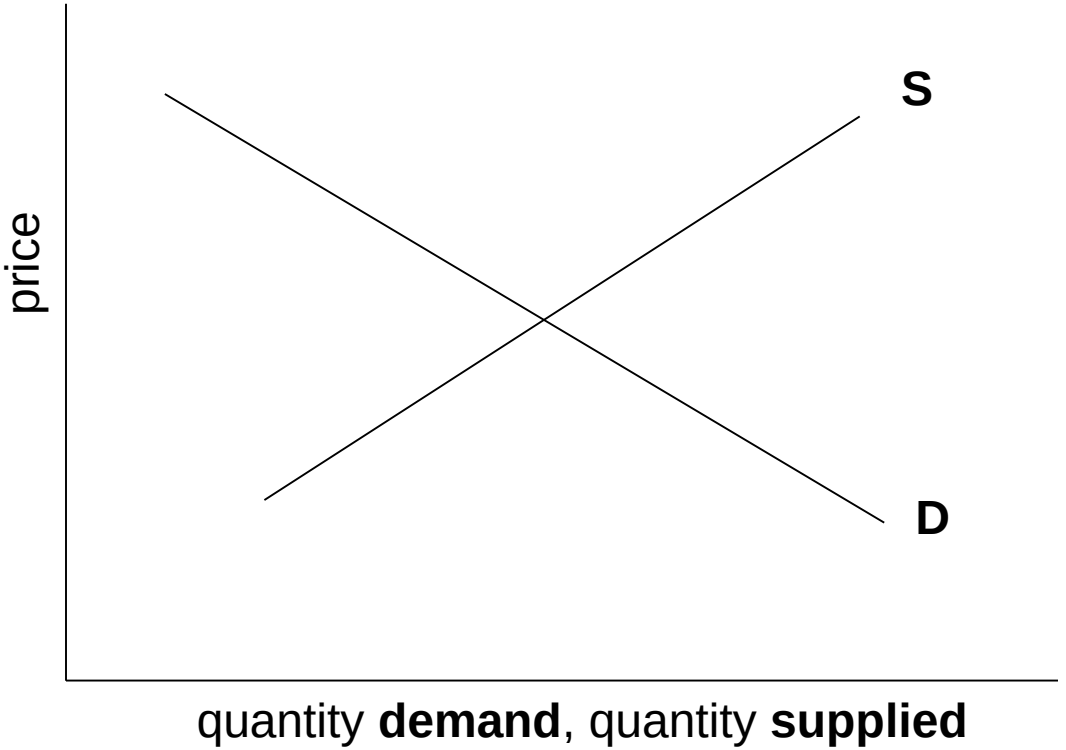
What is a model?

What economic model is most well known?

Draw that model.

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

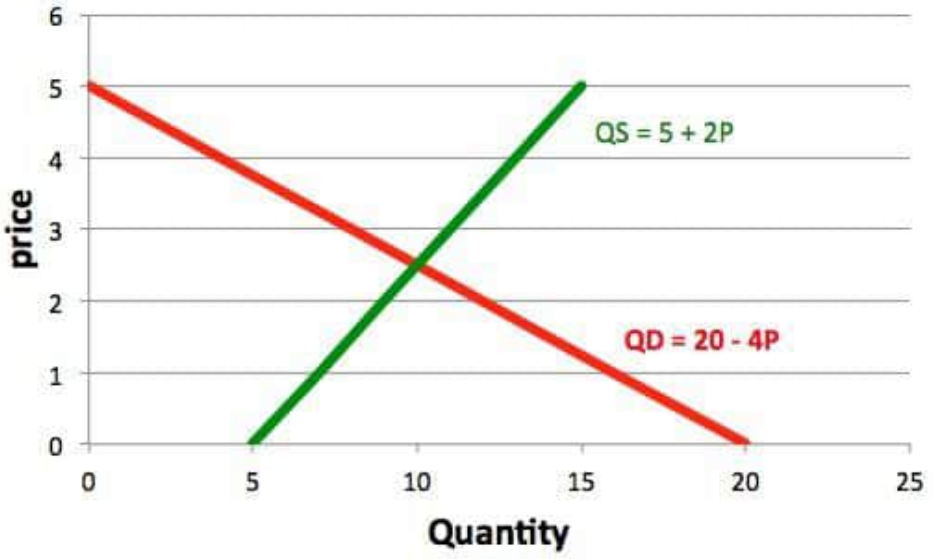
What is “cause” and what is “effect” in this model?



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*

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

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

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

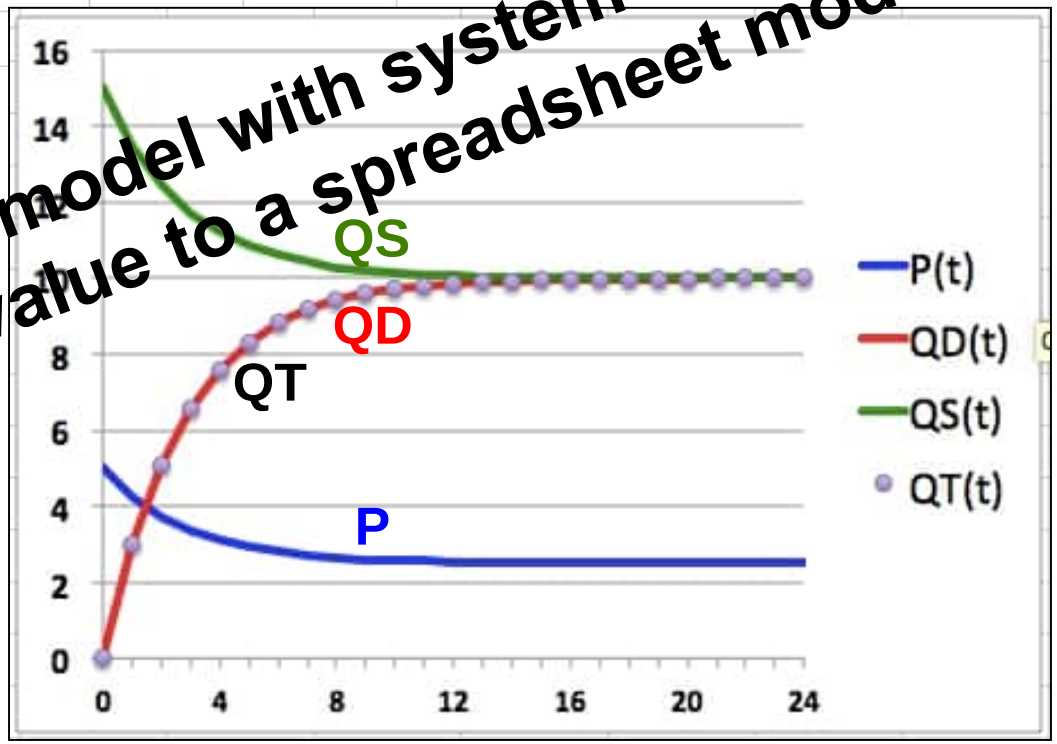
$QT(t) = MIN(QD(t), QS(t))$

$a = 0.05$

$p^* = 2.5$

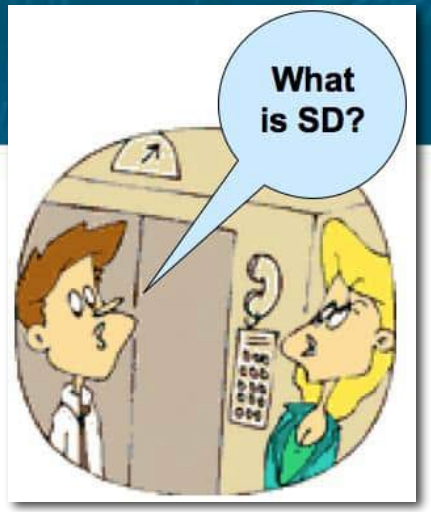
$q^* = 10$

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



Can we build this model with system dynamics?
Would SD add value to a spreadsheet model?

System Dynamics

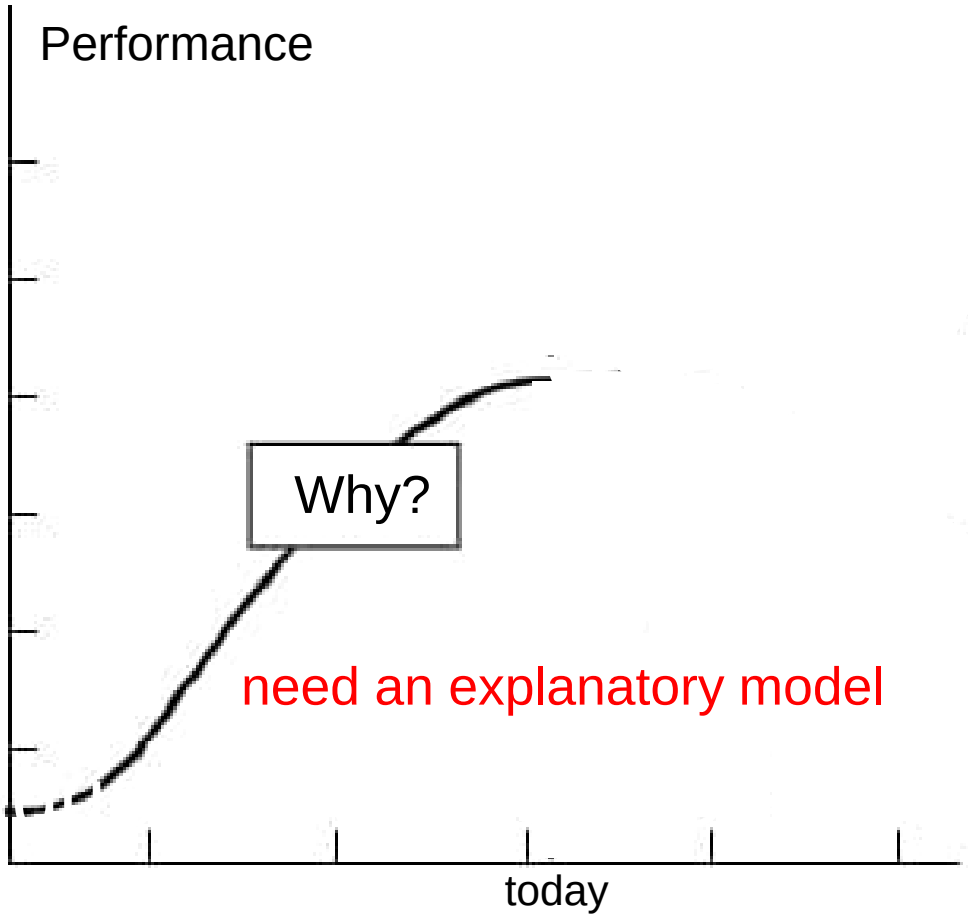


A simulation modeling approach
to the *study* and *management* of
dynamic problems in socio-economic systems.

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. **explanatory model**
- To alleviate problematic dynamic behavior, re-design the underlying structure. **policy model**

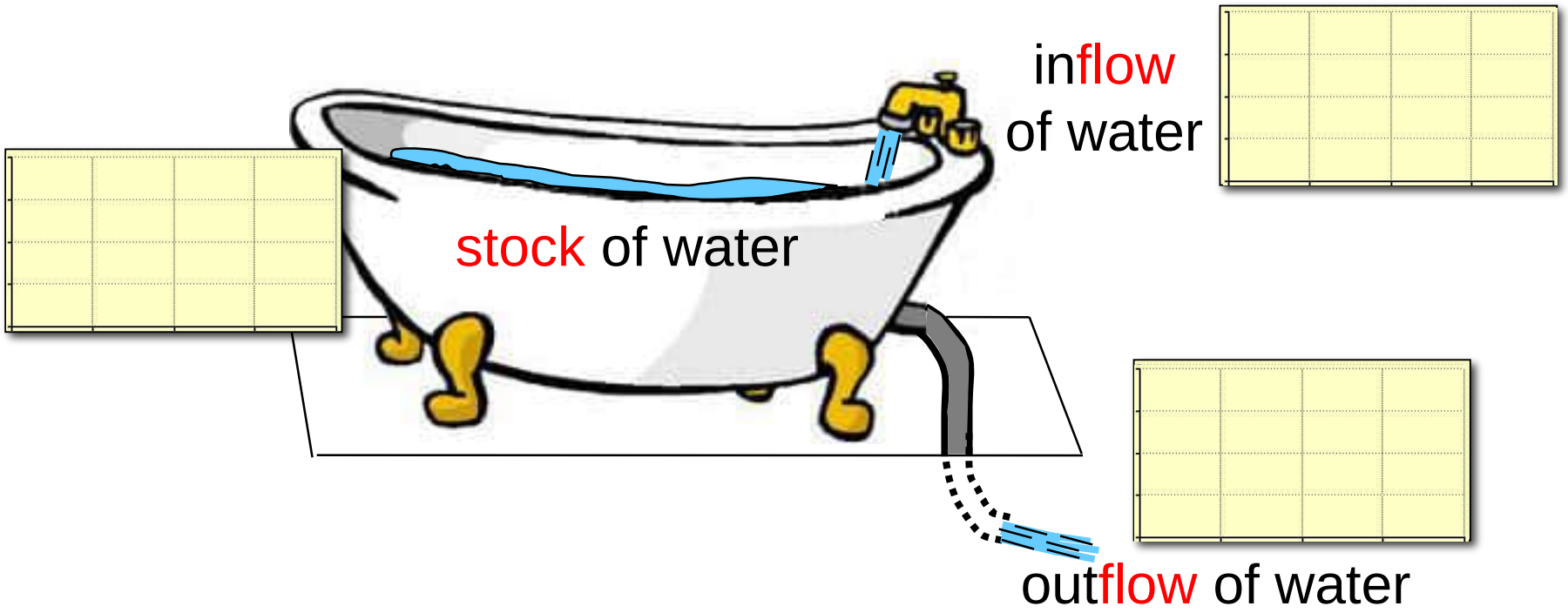
What questions does SD seek to answer?



need a policy model

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

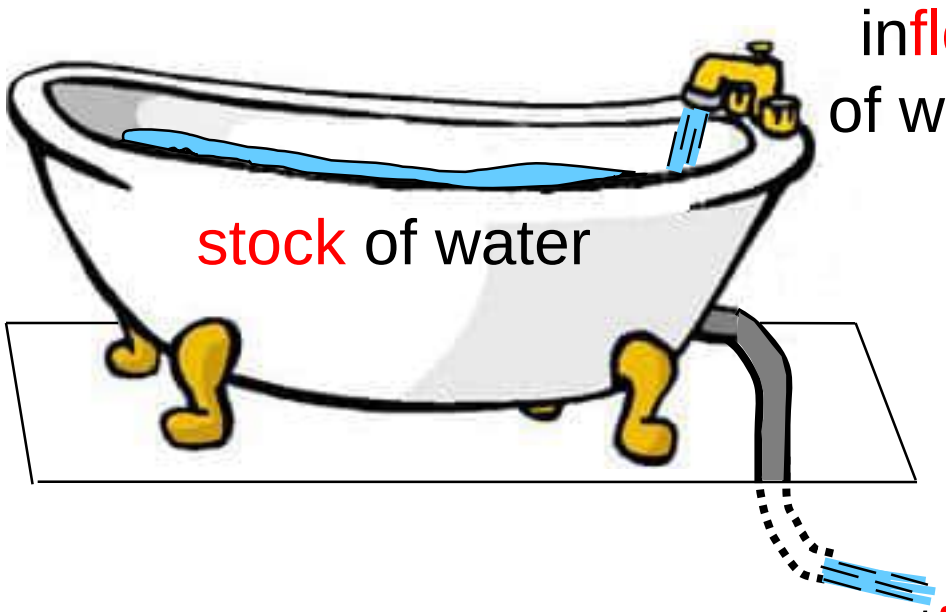
Structure and Behavior



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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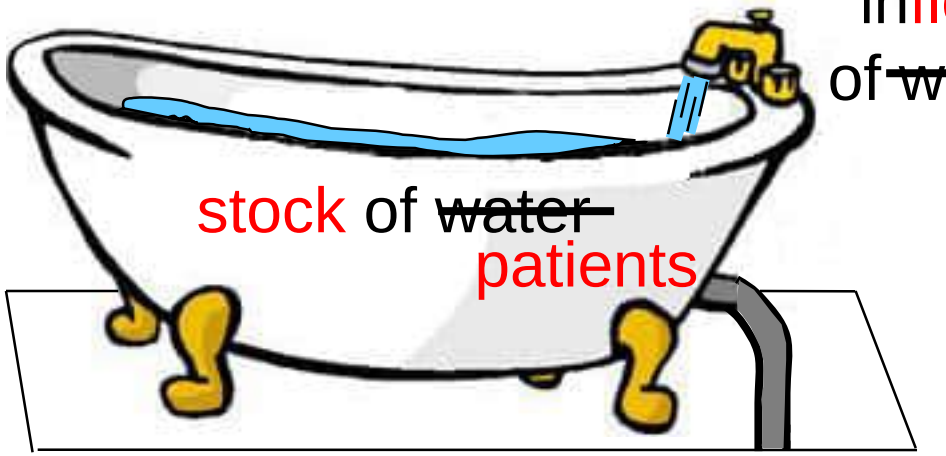

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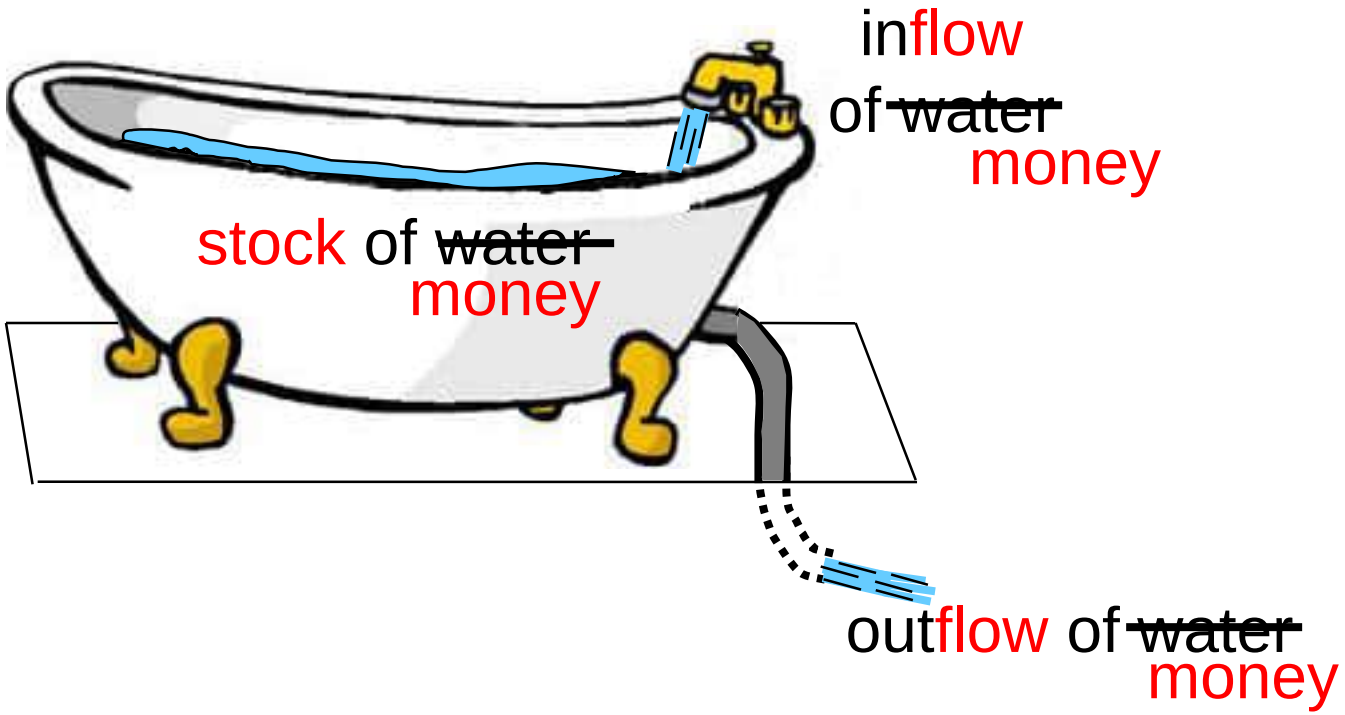

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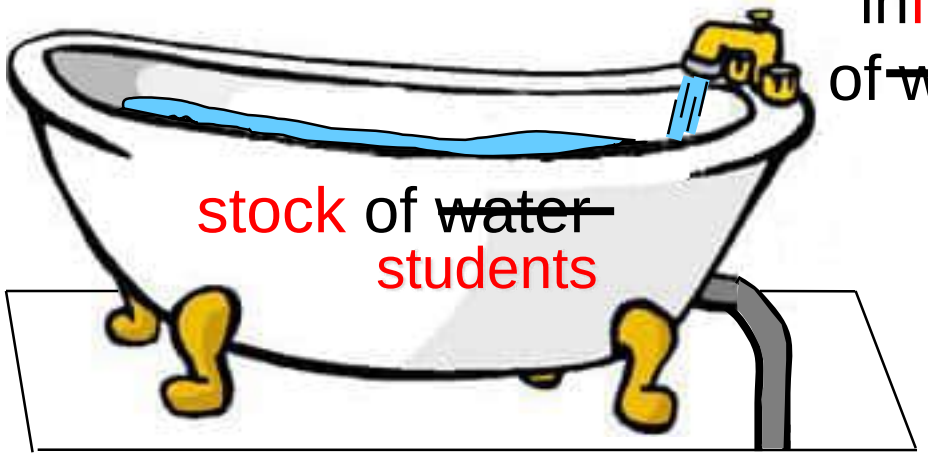
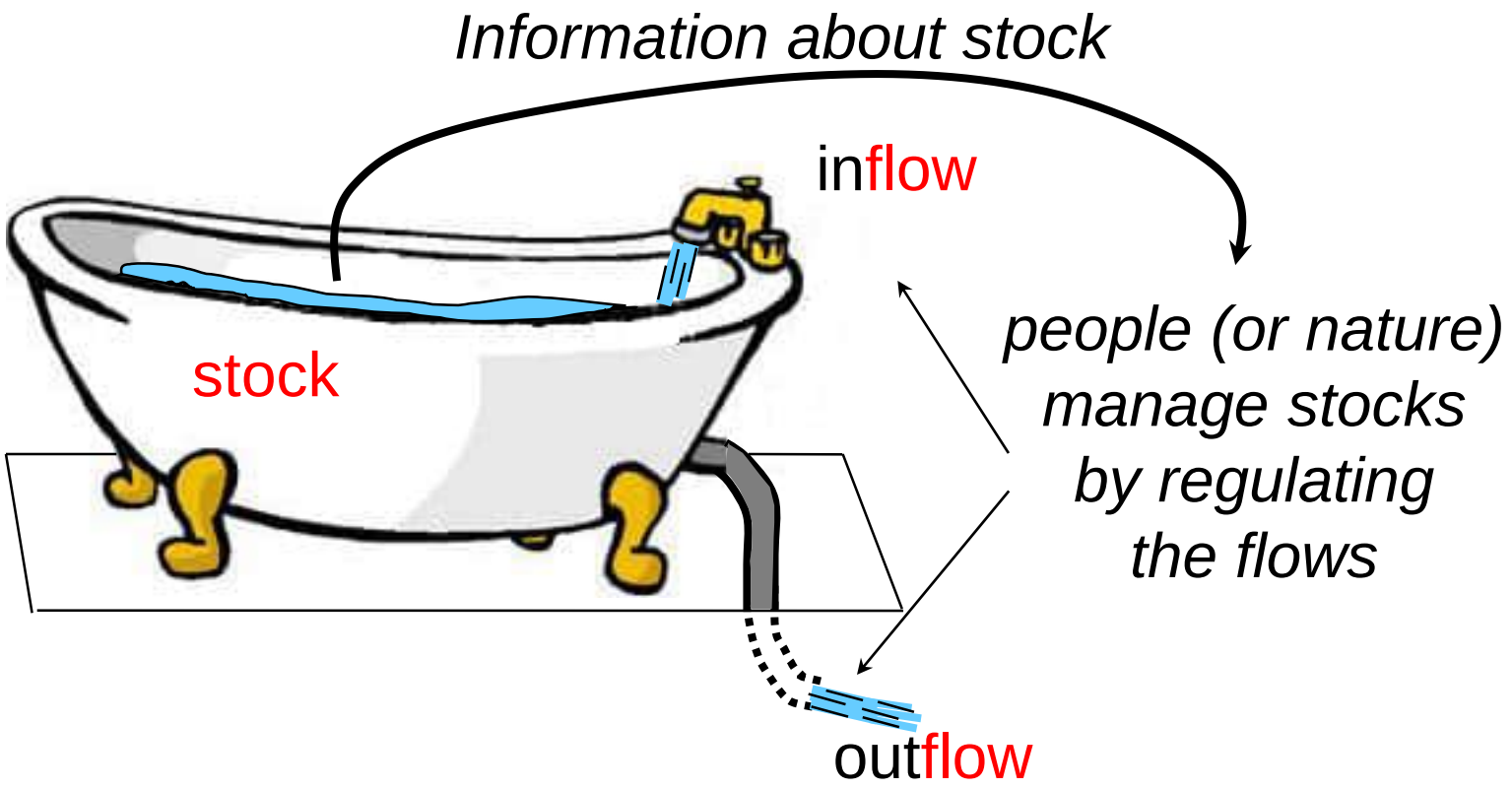
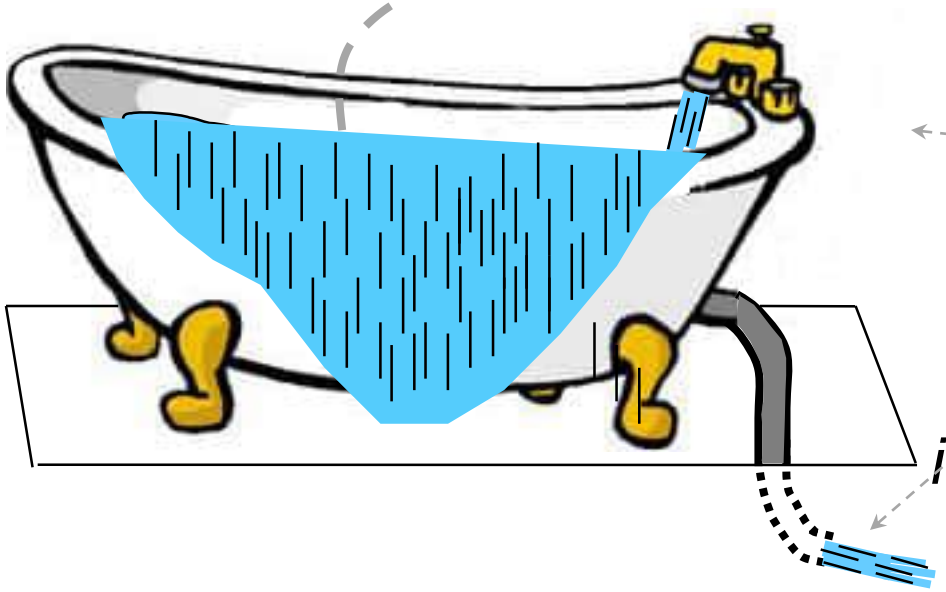


Feedback Thinking



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

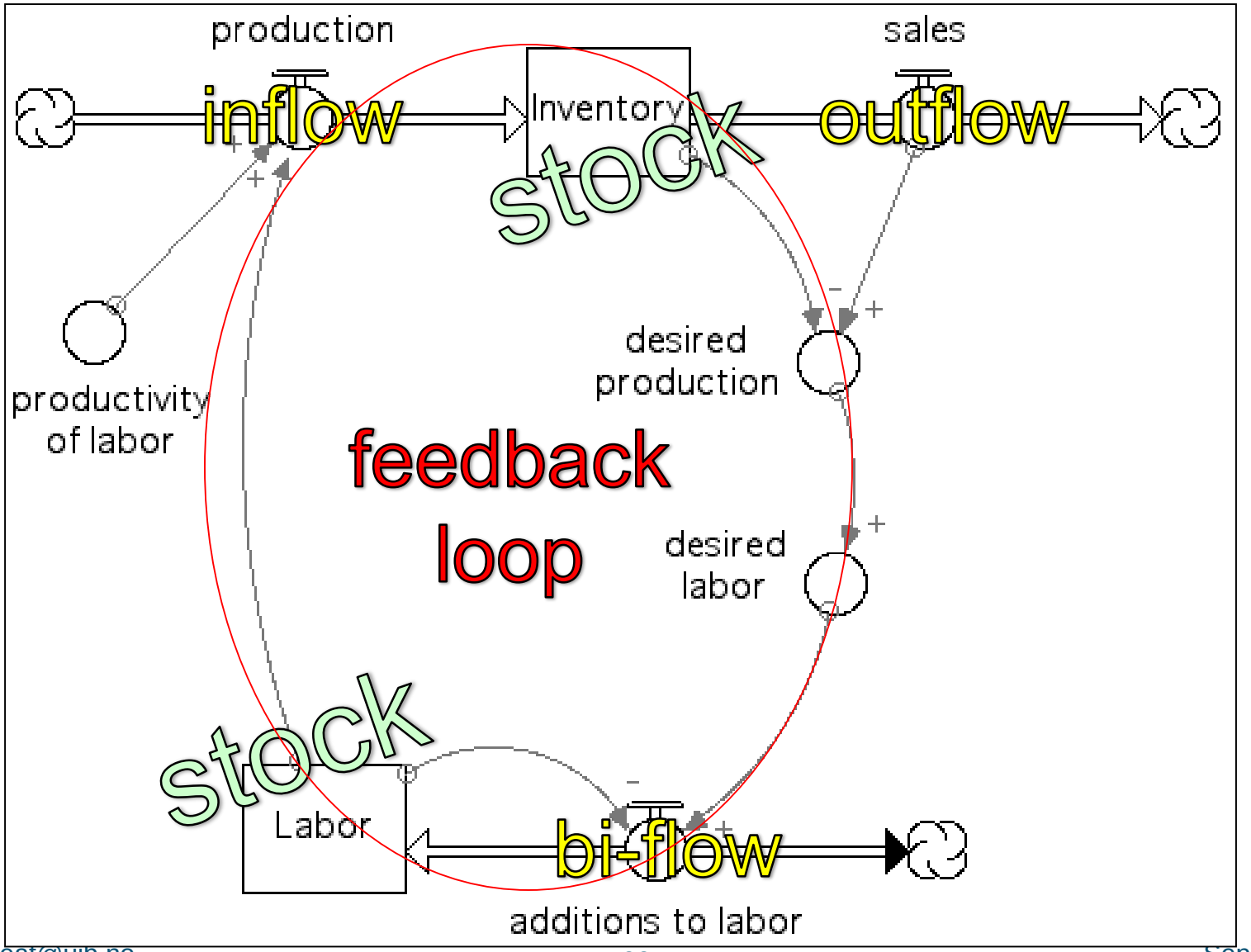


Sometimes flows are poorly regulated, causing stocks to be mismanaged.

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.

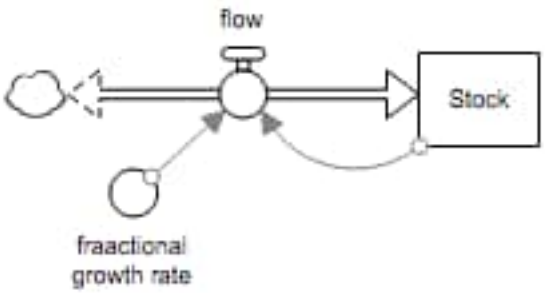
Stocks, Flows, Feedback



Some Common Flow Equations

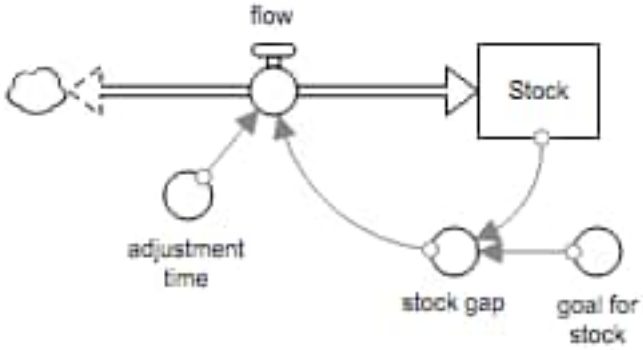
1. Fractional growth rate

Flow = stock * fractional growth rate



2. Explicit Goal-Seeking

Flow = stock gap / adjustment time



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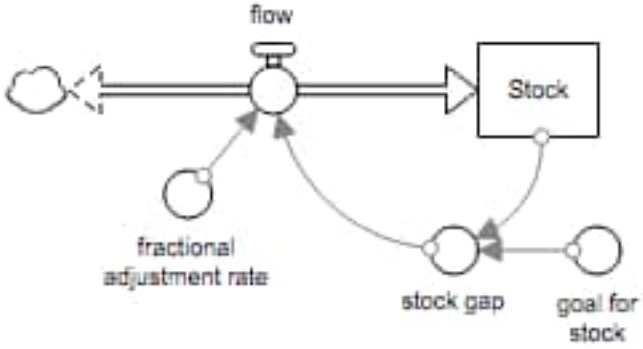
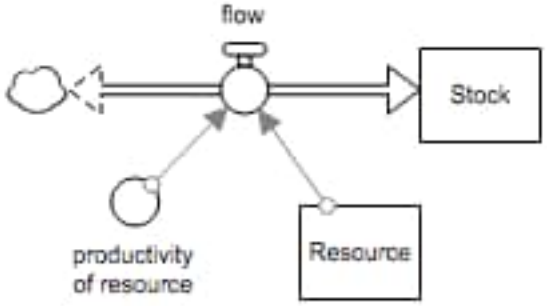


3. Production function

Flow = resource * productivity of resource



Fractional Growth Rate

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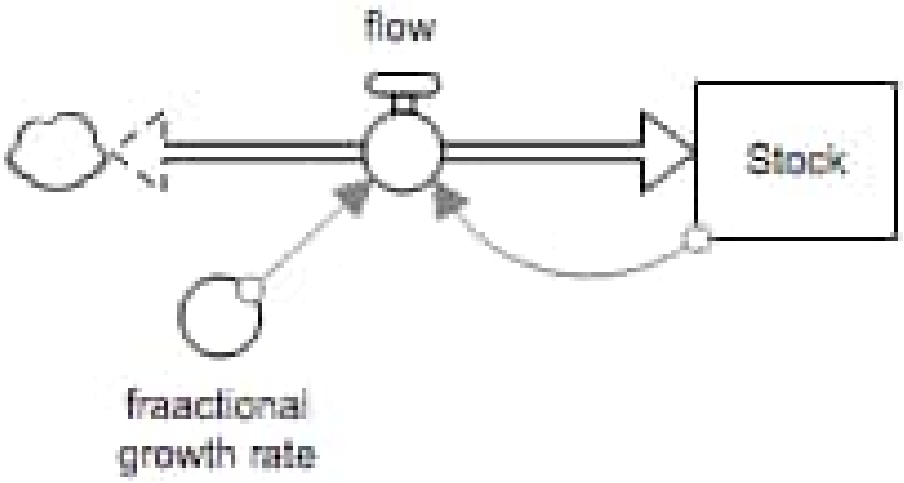
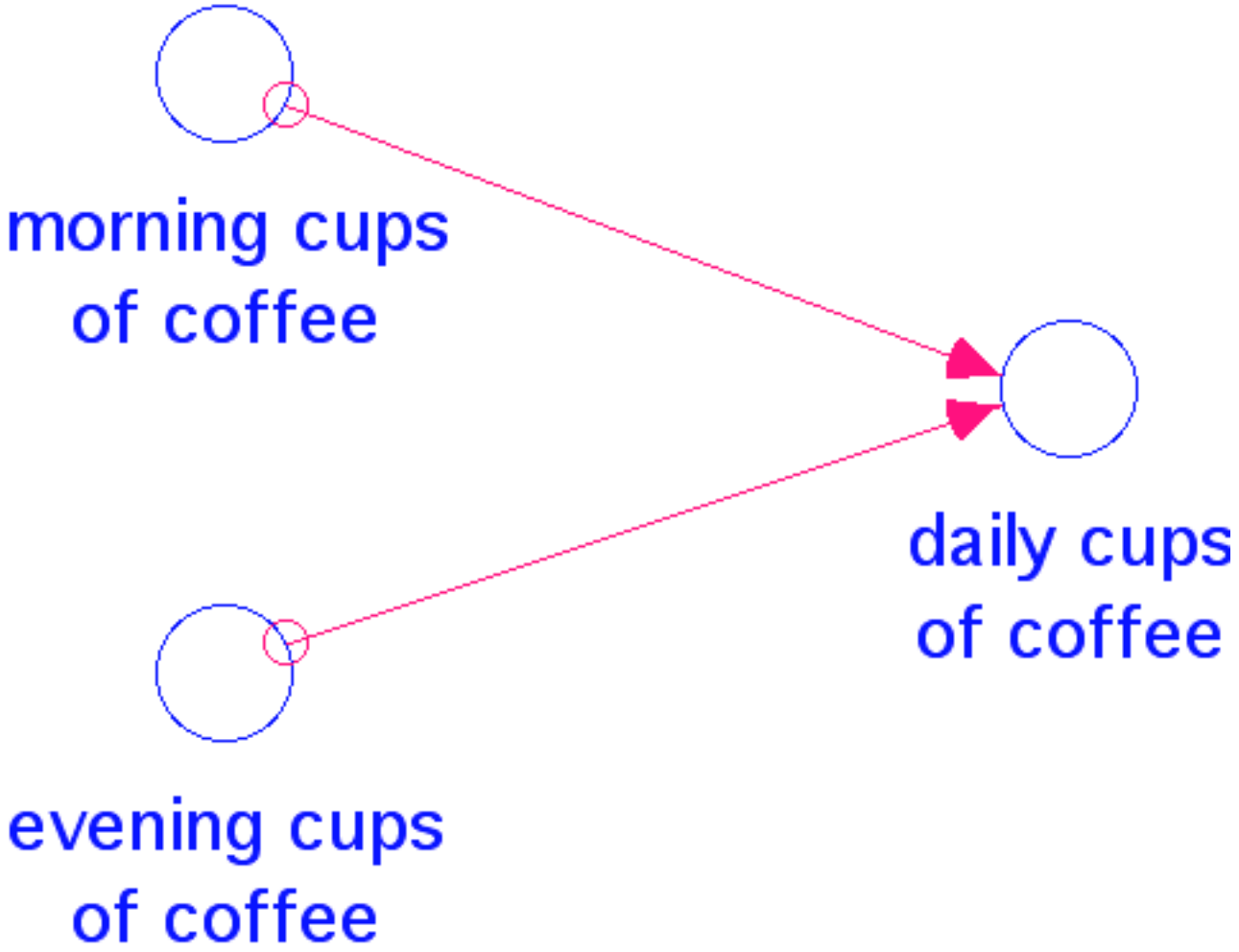


Why Units are Helpful when Formulating Equations



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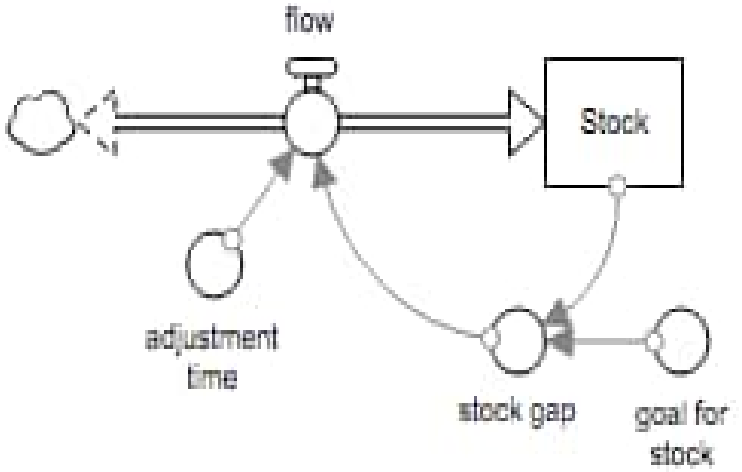

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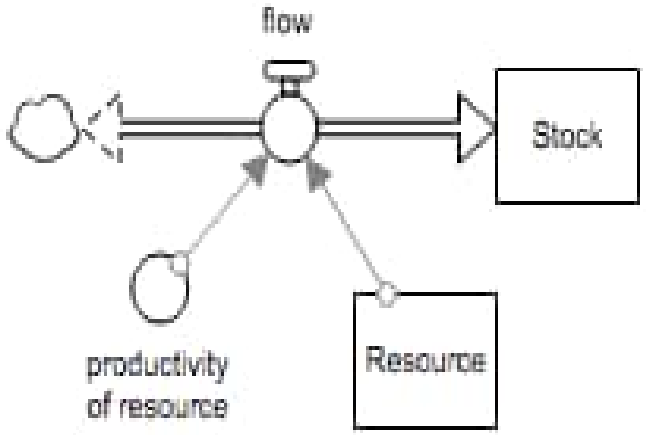

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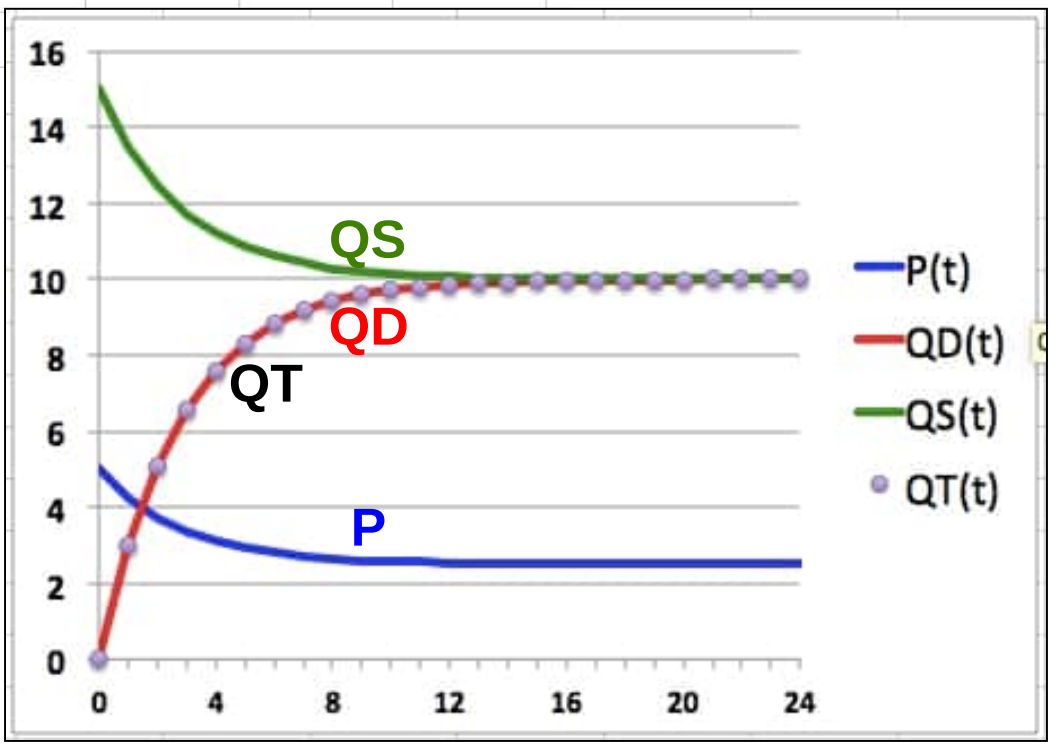
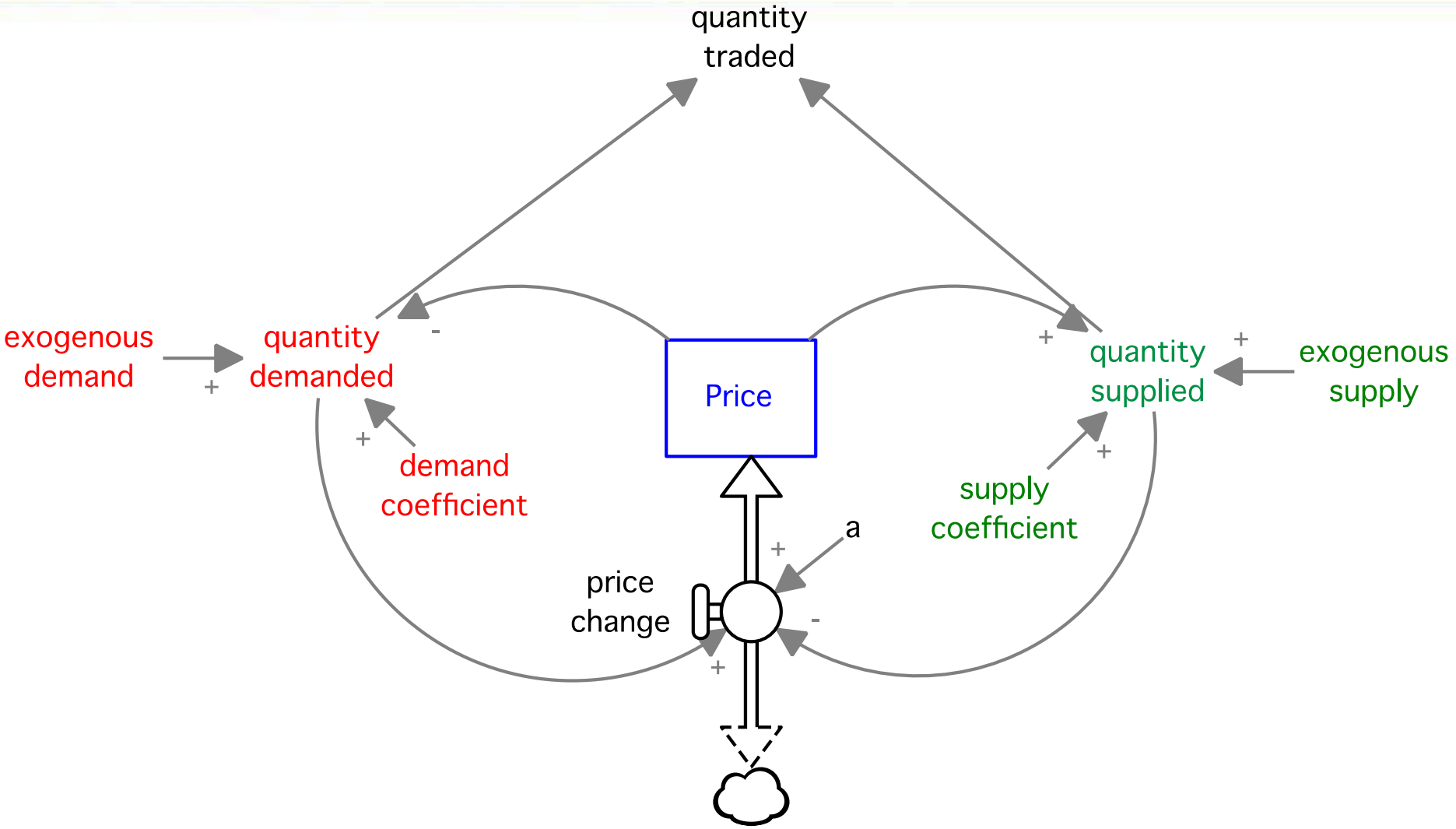


Model 2.1a (System Dynamics version)



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

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5. Build SD model 2.1a, based on spreadsheet model and online model*

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alina.fin.2008@gmail.com
david.wheat@uib.no
olisk@ukr.net
*zip all files before emailing, and use this format for file names:
LastNameFirstName YYMMDD
e.g., HarrisEmmylou 180904

Biographical Sketch

I. David Wheat

Professor of System Dynamics, University of Bergen, Norway
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, and the Euro Area.

He teaches monetary policy, economic dynamics, and dynamic macro analysis 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 masters-level 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 is working with economists at Lithuania's central bank to develop a multi-industry system dynamics model of price dynamics in Europe. In addition, he manages a system dynamics-based public health education project for the University of Bergen in Norway and the University of North Dakota in the United States.

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." He also seeks to improve the practical value of system dynamics models by adding implementation insights gleaned from the public policy literature. Two recent book chapters on that topic are "Model-based Policy Design that Takes Implementation Seriously" and "Disappointing Outcomes: Can Implementation Modeling Help?"

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 guest lectures in many countries. For three decades, he was president of Wheat Resources Inc, a consulting firm serving business and government clients. His current economic modeling consulting firm is Praktika LLC. 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.