

END4400 – System Dynamics

Week 1 – 9/3/2021

Assist. Prof. Mert Edalı
medali@yildiz.edu.tr

Outline

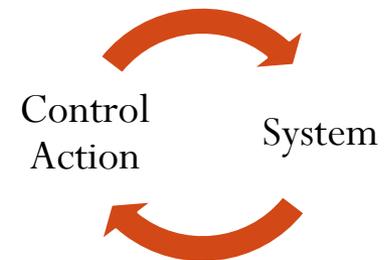
- Course Syllabus
- Basics of System Dynamics

Basic Definitions

- new century
 - economic growth → environmental/ecological problems
 - fast (and unbalanced) growth and then the collapse of small companies
 - welfare gap between “north” and “south” nations
 - exponentially growing new cases in the pandemic
- common points
 - dynamic, long-term policy problems
 - dynamic → changing over time, require dynamic and continuous actions

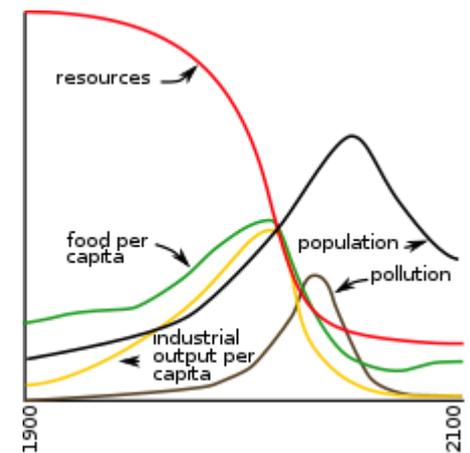
Basic Definitions

- Dynamic vs. static problems
 - Dynamic → continuous managerial action (e.g., inventory)
 - Static → decision is made only once (e.g., facility location)
- Dynamic problems
 - “feedback problems” → between the control action and the system
 - not only between the control action and the system!
- problems are “systemic” → caused by the interactions between the variables in the system



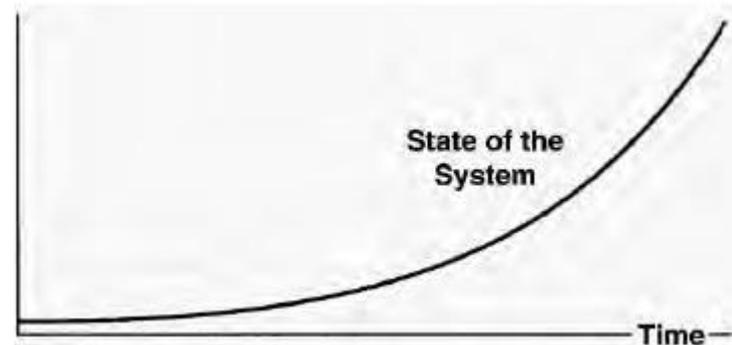
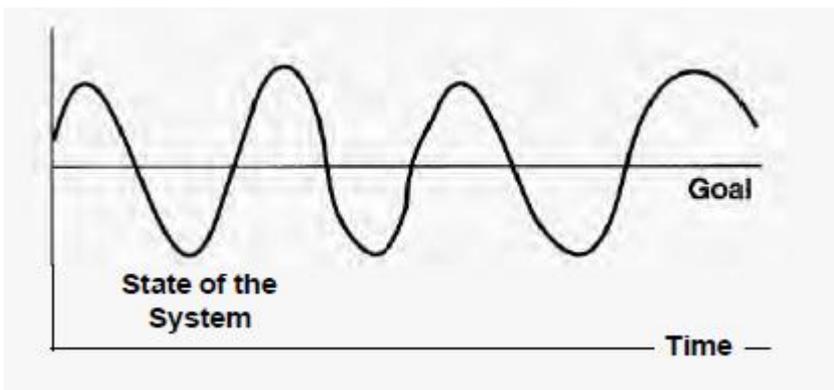
History of SD

- emerged in the late 1950s under the leadership of Jay Forrester at MIT
- “industrial dynamics” → a famous book
 - industrial/business problems
- “urban dynamics” → interaction between industry, housing, and people
- “world dynamics” → population growth and economic development → overshoot and collapse dynamics

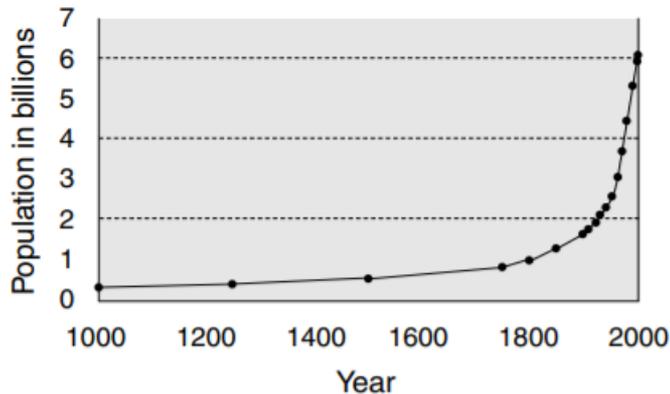


Basic Definitions

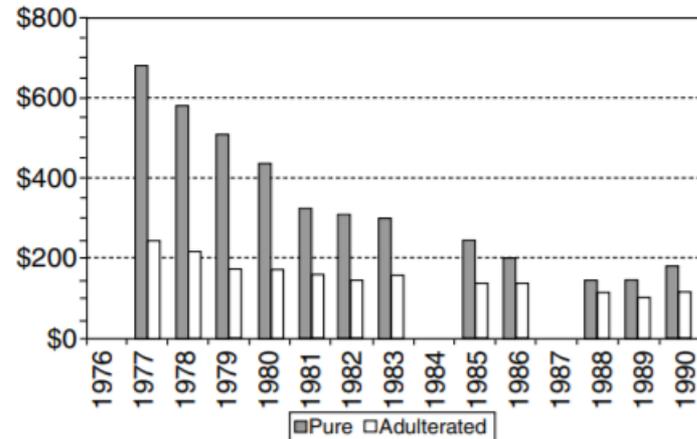
- “dynamic” → changing over time, in motion
- “dynamic problems” → variables having significant changes over time
 - inventory and order oscillations
 - increasing levels of solid waste, air and water pollution
 - blood pressure, body temperature
- these dynamic problems must be controlled, altered or reversed



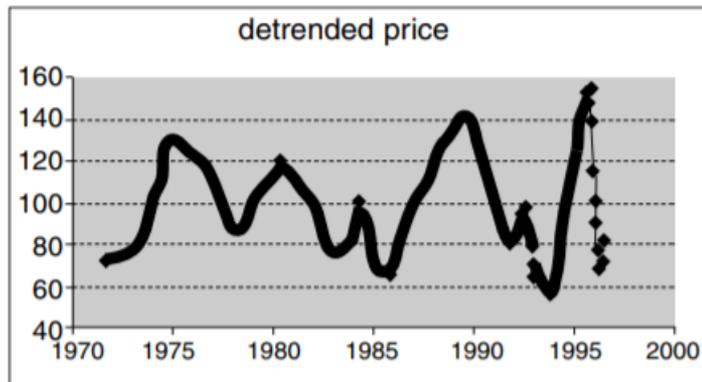
Basic Definitions



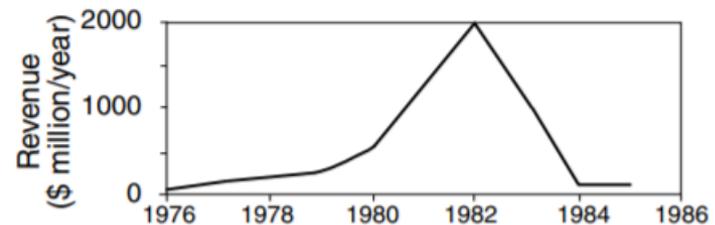
(a) World population growth (See "The ECOCOSM Paradox," EOLSS on-line, 2002).



(c) Retail price per gram of cocaine (in 1990 dollars) (See "A Dynamic Model of Cocaine Prevalence," EOLSS on-line, 2002).



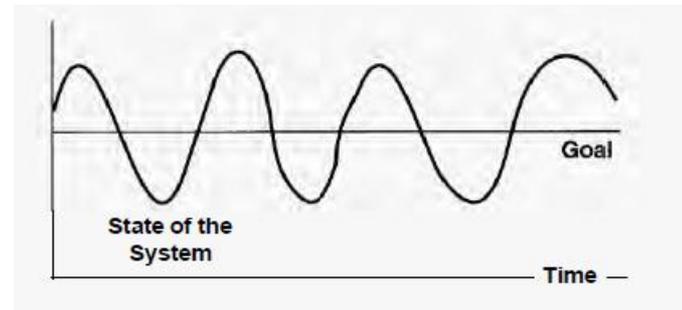
(b) USA pulp prices (Deflated by CPI and all trends removed)



(d) Boom and bust: sales and operating income of Atari, Inc. (See "Market growth, collapse and failure to learn from interactive simulation games," EOLSS on-line, 2002).

Basic Definitions

- in addition to “dynamic variables”, unwanted dynamics are generated within the system (internally)
 - “endogenous” → not caused by external forces
 - generated by the feedback mechanisms
 - e.g., inventory oscillations are caused by the interaction of ordering and production policies of managers
 - “the decisions that you make creates the oscillations” → not caused by an external force
 - external force → e.g., fluctuating weather conditions (still dynamic but “uninteresting”)



Basic Definitions

(System, Problem, Model)

- “system” → a collection of interrelated elements, forming a meaningful whole
 - a financial system
 - a political system
 - a production system
- many elements interacting in a meaningful way so that the system can serve its “purpose”
 - production system → producing the desired quantity within a given time frame
 - not trivial → “unintended consequences”

Basic Definitions

(System, Problem, Model)

- “model” → a representation of selected aspects of a real system with respect to some specific problem(s)
 - we do not model a system!
 - without a problem, modeling is meaningless!
 - the motivation behind modeling is a problem!
 - modeling starts with a dynamic problem of concern
 - a species population ✘
 - model of selected factors believed to play a strong role in an unstoppable decline in the population of a species of concern ✓
 - “selected aspects” → include factors believed to cause the undesired dynamics

Basic Definitions

(System, Problem, Model)

- models can be categorized with respect to different criteria
- physical/symbolic models
 - physical → airplane, architectural
 - symbolic → diagrams, graphs, mathematical equations (SD models)
- static/dynamic
 - static → variables do not change over time (e.g., architectural model, math. equation price/supply/demand)
 - dynamic → represent how variables change over time (e.g., flight simulator, Newton's laws of motion)

Basic Definitions (System, Problem, Model)

- descriptive/prescriptive
 - descriptive → how the variables interact and how the problems are generated
 - do not say anything about how the system should function to eliminate the problem
 - prescriptive → aim to find “optimum” decision under a set of constraints to max/min “objective function(s)”
 - SD models are descriptive!

Basic Definitions

(System, Problem, Model)

- continuous/discrete
 - continuous \rightarrow change can occur at any time point (e.g., air temperature, humidity, population)
 - discrete \rightarrow change occurs at pre-defined discrete points in time (e.g., GPA of a student can change at the end of each semester)
 - SD models can have both types of dynamics. (continuous/discrete/hybrid)
 - If the time horizon of the model is long enough, one can assume time-continuity.
 - continuous-time models \rightarrow differential or integral equations
 - discrete-time models \rightarrow difference equations

Basic Definitions

(System, Problem, Model)

- Homework: Read until Section 2.3 (excluding) of Barlas (2002)

- References

Barlas, Y. “System Dynamics: Systemic Feedback Modeling for Policy Analysis” in Knowledge for Sustainable Development - An Insight into the Encyclopedia of Life Support Systems, UNESCO-EOLSS Publishers, Paris, Oxford, UK. 2002, pp.1131-1175.

Sterman, J. Business Dynamics. Systems Thinking and Modeling for a Complex World. McGraw-Hill, U.S.A., 2000.