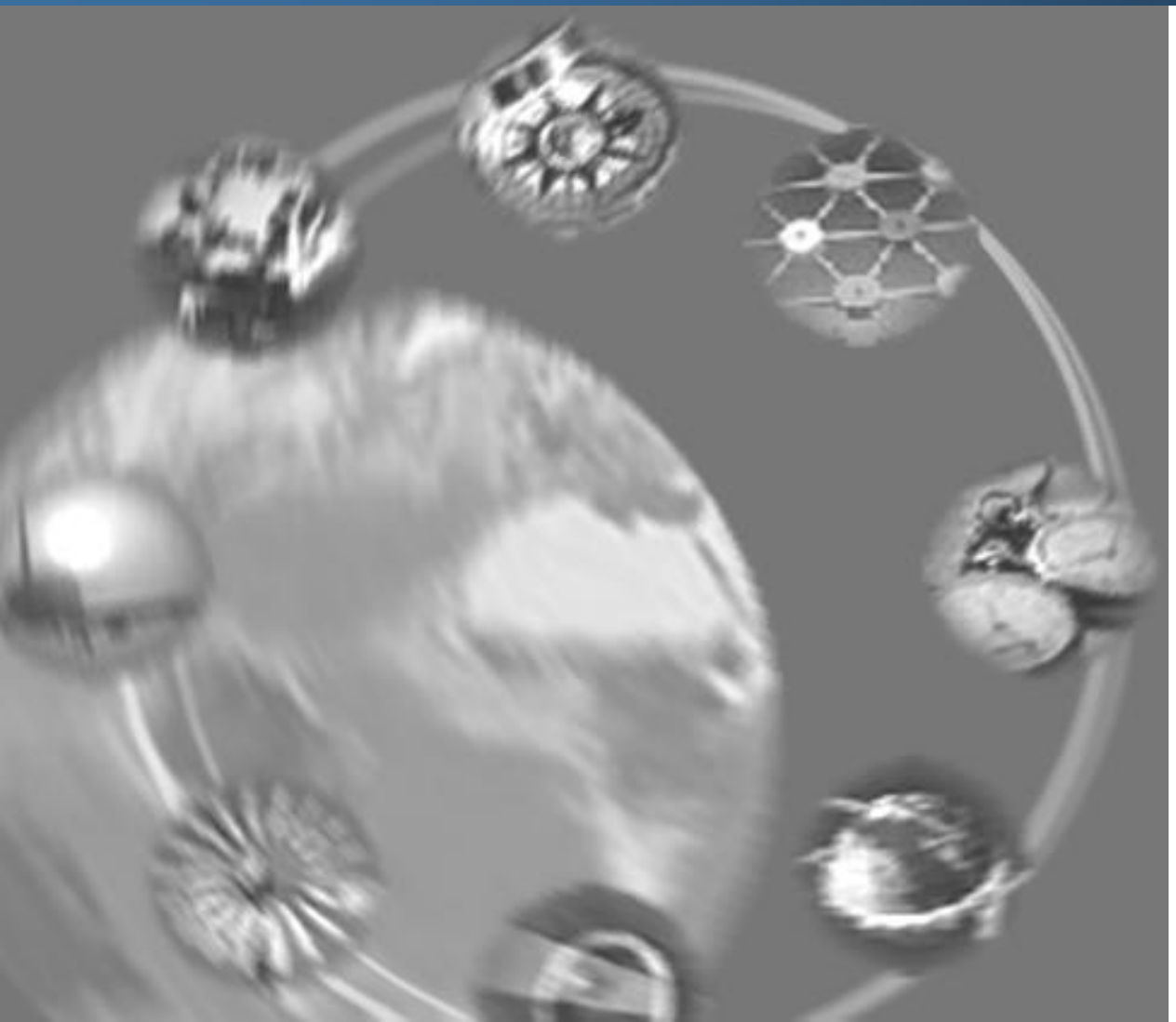
Where Did the Gasoline Go?

Identifying Stock & Flow Structure



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Dynamic vs. Static

	Dynamic system	Static system
OUTPUT changed by	current INPUT/System Status(past IN/OUTPUT)	current/past INPUT
System characteristics	having MEMORY Variables (not only OUTPUT) changed by TIME Including energy storage	instantaneous system (no MEMORY)

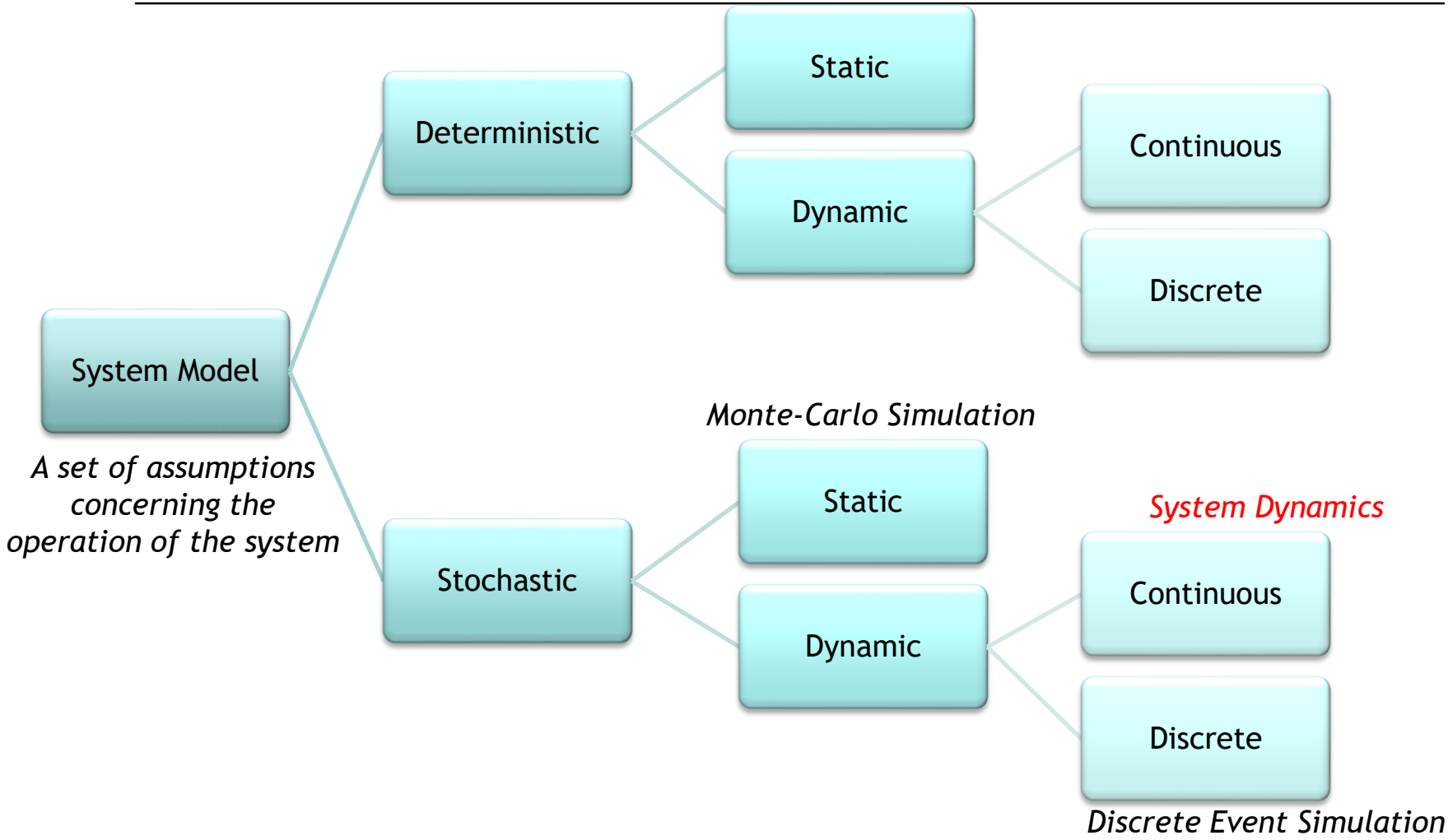
Deterministic vs. Stochastic

- Deterministic models: output fully determined by the parameter values and the initial conditions.

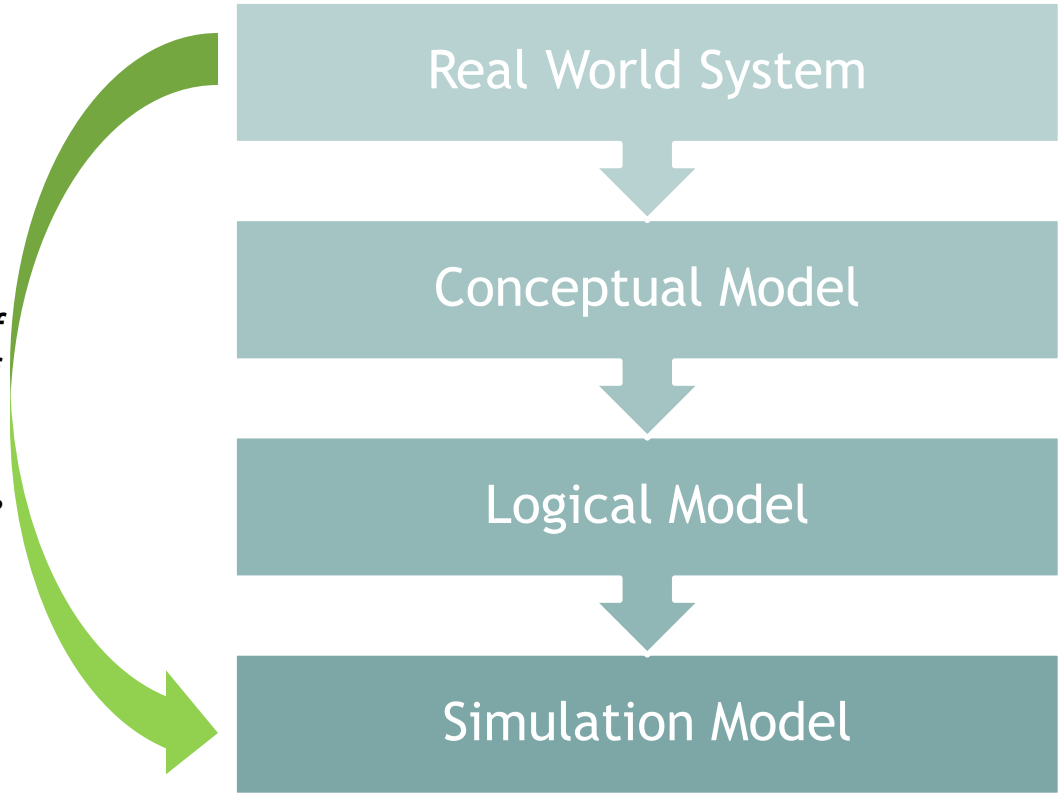
- Stochastic models: possess inherent randomness. The same set of parameter values and initial conditions will lead to an ensemble of different outputs.

https://www4.stat.ncsu.edu/~gross/BIO560%20webpage/slides/Jan102013.pdf

Taxonomy of Simulation Models



Validation vs. Verification



VALIDATION

The process of determining if the model accurately represents the system

VERIFICATION

The process of determining if the operational logic is correct

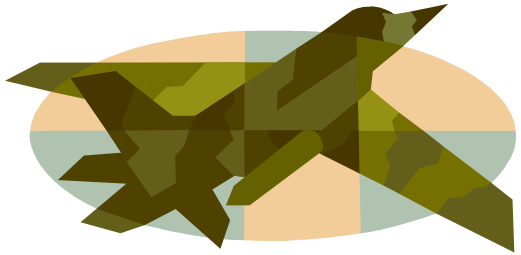
Lecture Outline

- Contribution of Stocks to Dynamics
- Identifying Stock and Flow Structures
- Mapping Stock and Flow Structures
- Where did the gasoline go?

Characterize the state of the system

Provide decision-makers with the basis for actions

- Pilot: aircraft's position, heading, altitude, fuel level



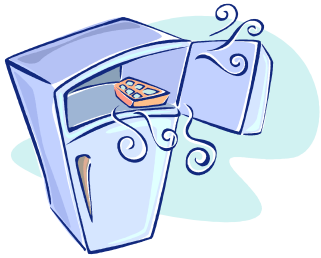
- Firm: order backlog, inventory stocks, labor force
- Balance sheet: cash, inventory, payables, debt

Provide systems with inertia and memory

Stocks accumulate past events.

- Lead in the paint of housing remains high (banned in 1978).

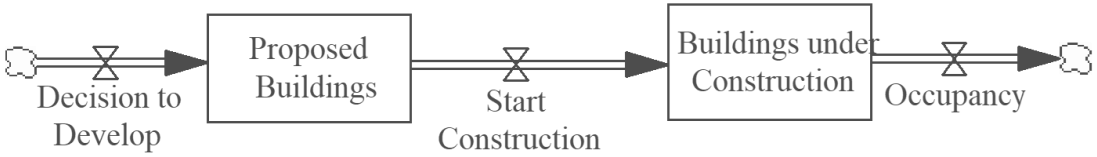
- Ozone-destroying chloride by CFC will remain for decades.



- Beliefs persist over time, generating inertia and continuity in attitude and behavior.

The source of delays

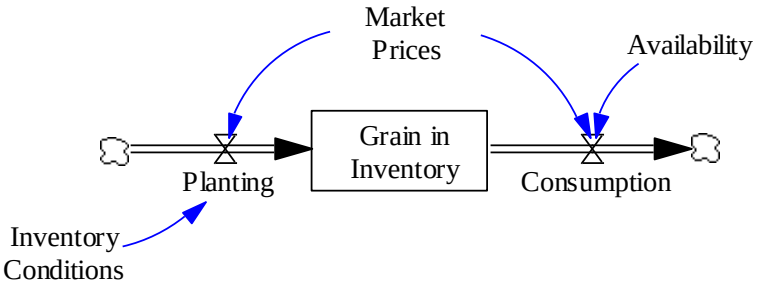
A delay is a process whose output lags behind its input. The difference between the input and output accumulated in a stock of material in process



Create disequilibrium dynamics

Stocks absorb the differences between inflows and outflows, permitting them to differ. As a result, disequilibrium is the rule rather than the exception.

- What if there is no buffer or stock?
- Whenever controlled by different decision makers, subject to random shocks, a buffer or stock must exist.
- Whether/how equilibrium is achieved is an emergent property of a system.



Lecture Outline

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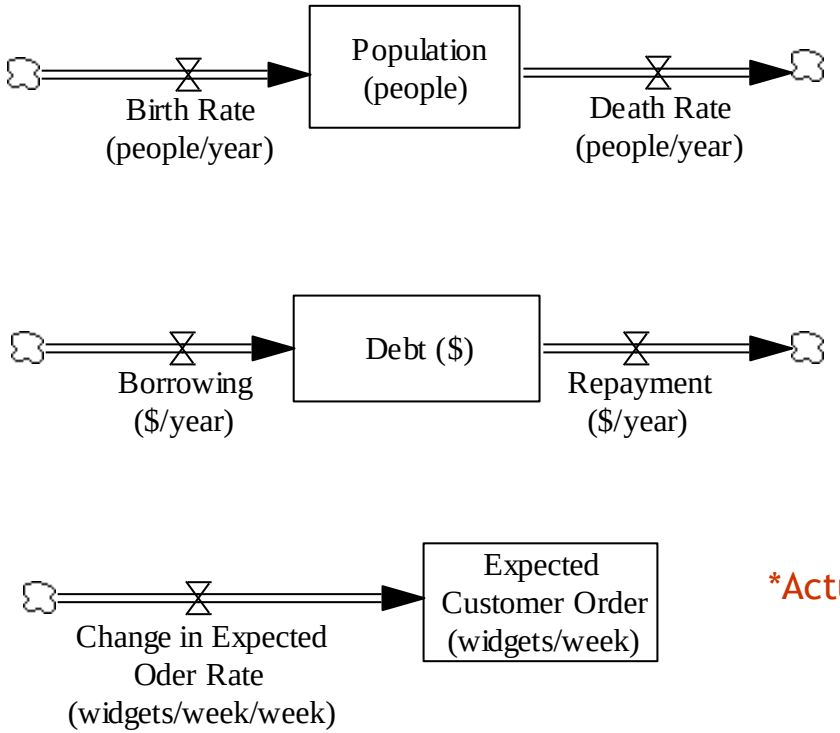
By units of measure

Items	Stocks	Flows	Units
Company sales		√	$/year
Phone calls on hold	√		calls
Workers	√		persons
GDP		√	$/year
Cash flow		√	$/year
On-going projects	√		units
Greenhouse gas emissions		√	tons/year
Price of product	√		$/unit
Employee morale	√		level
Depreciation		√	%/year
Construction work quality	√		level

The Snapshot Test



*Actual Customer Order:
a stock or flow?

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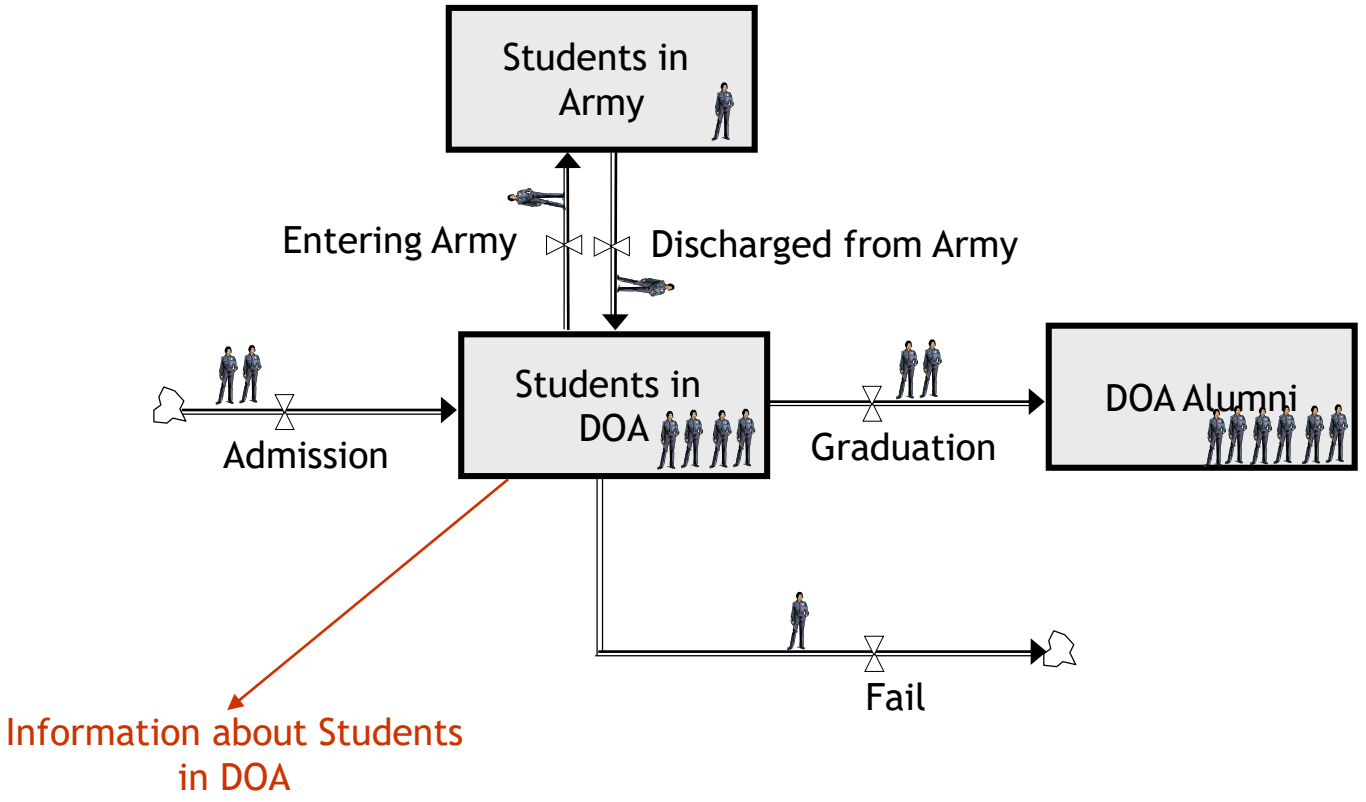
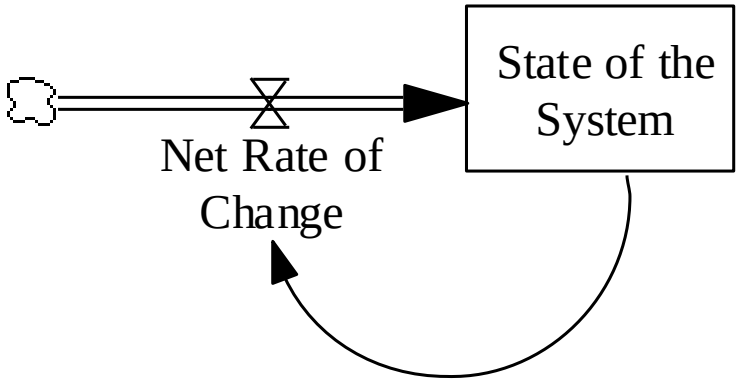
Conservation of Material in S&F



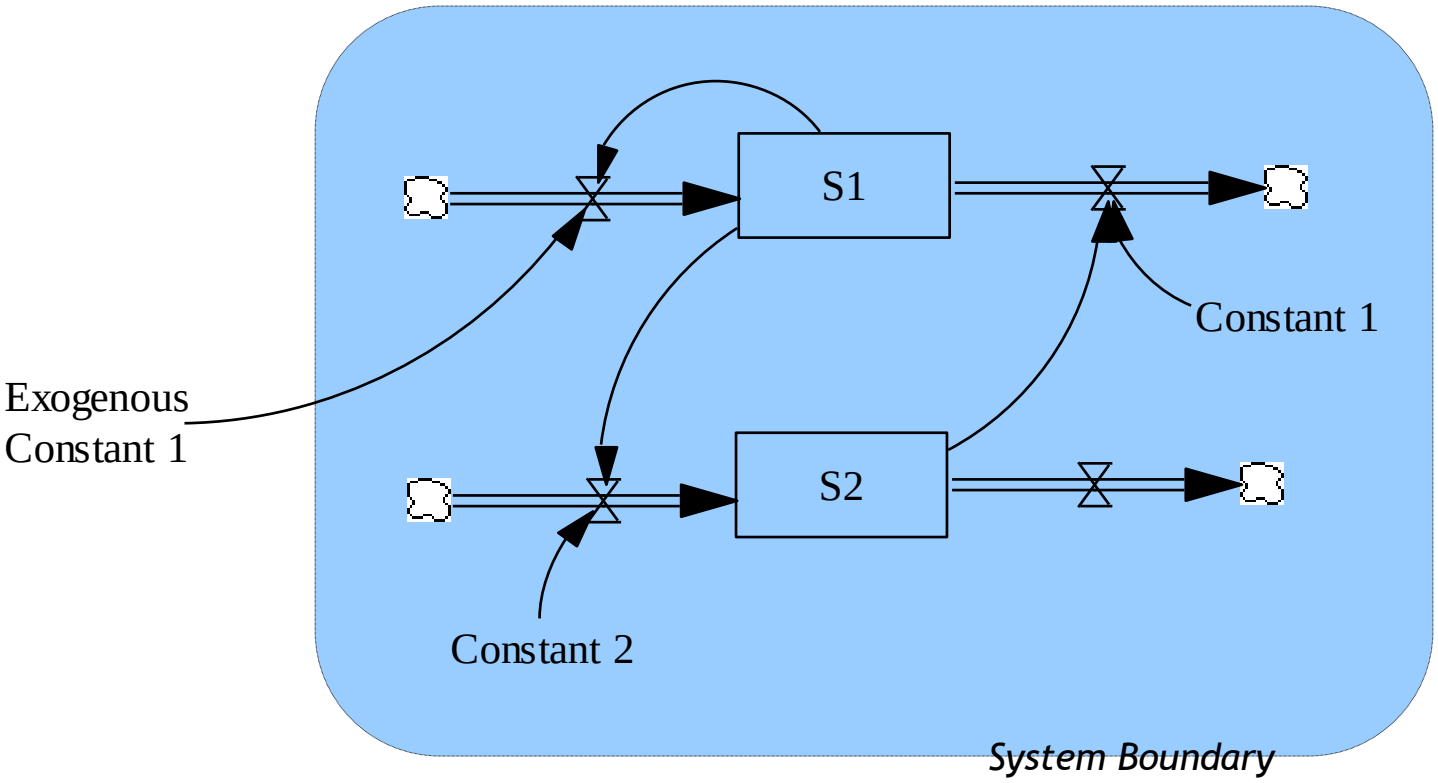
State-Determined Systems

Systems evolve by feedbacks of information from the state of the system to the flows, which in turn alter the states.

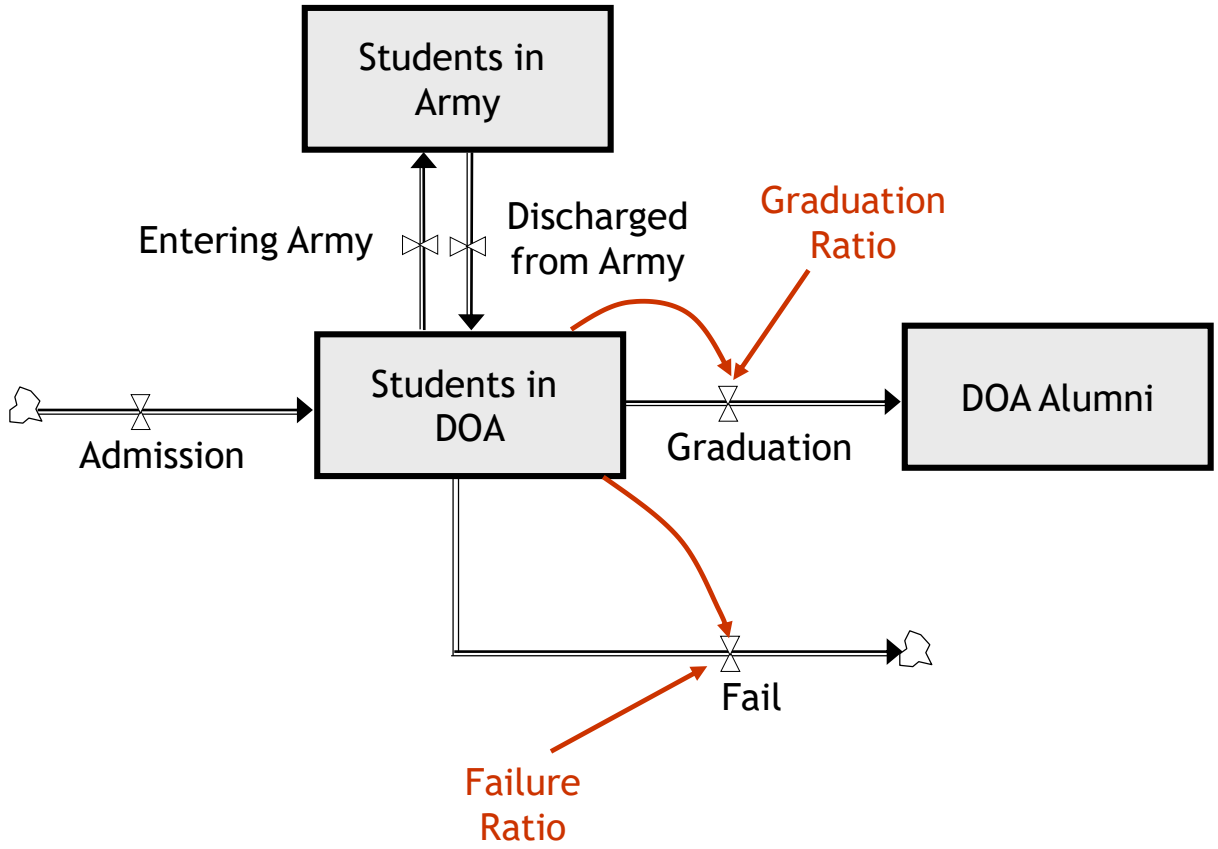


State Variables

State variables including constants (endogenous, exogenous) determine rates.



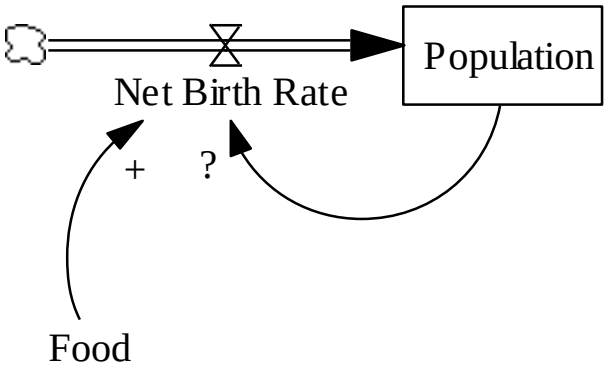
Examples


Students in Army
Entering Army
Discharged from Army
Graduation Ratio
Students in DOA
DOA Alumni
Admission
Graduation
Fail
Failure Ratio

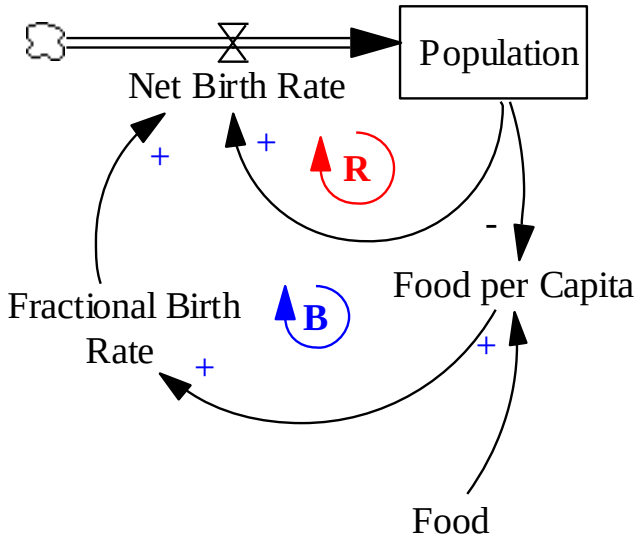
Auxiliary Variables

For easy communication and clarity, it is often helpful to define intermediate or auxiliary variables, which consist of functions of stocks (and state variables).

Incorrect



Correct



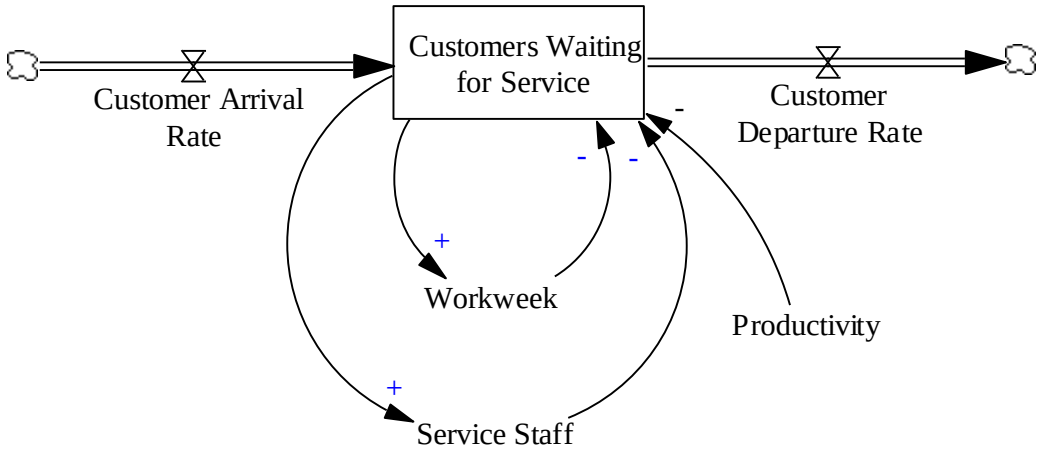
R: more people, more births, more people

B: more people, less food per person, lower fractional net birth rate, fewer births)

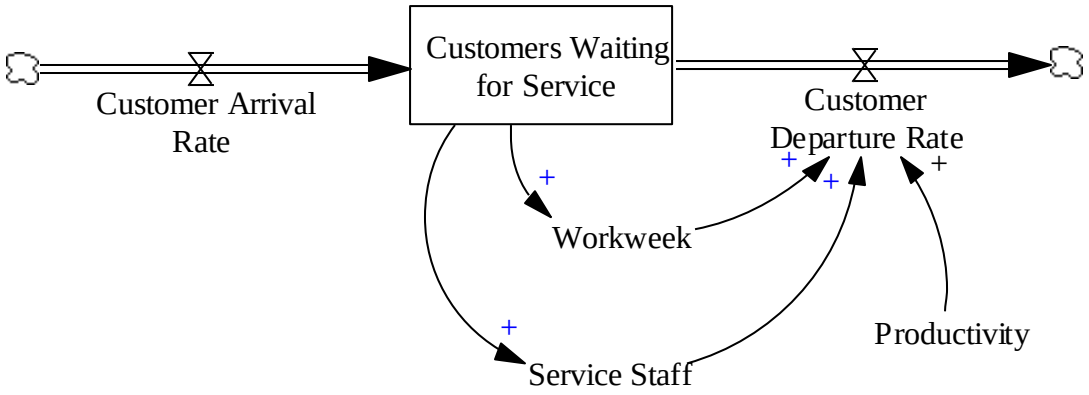
Stocks change only thru their rates

No causal links are allowed directly linked into a stock.

Incorrect



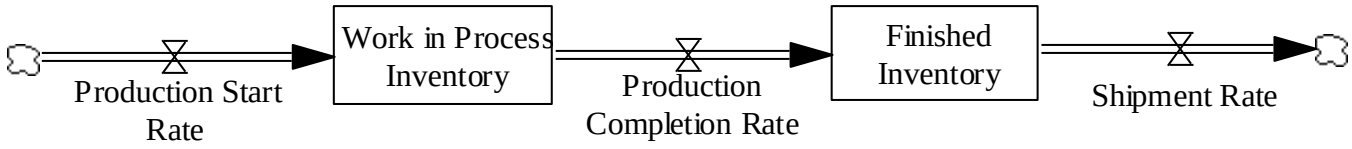
Correct



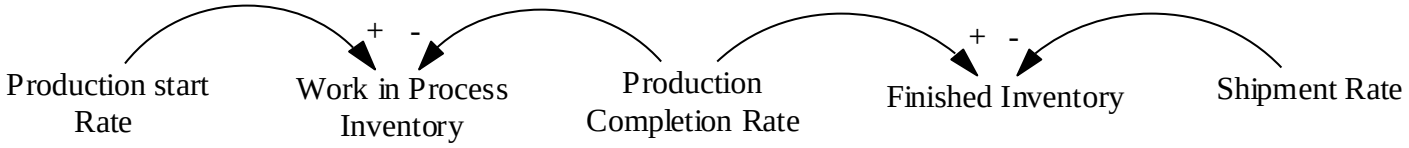
When to show S&F Structures?

When representing 1) physical processes, 2) delays, or 3) stocks whose behaviors are important in the dynamics you seek to explain.

S&F

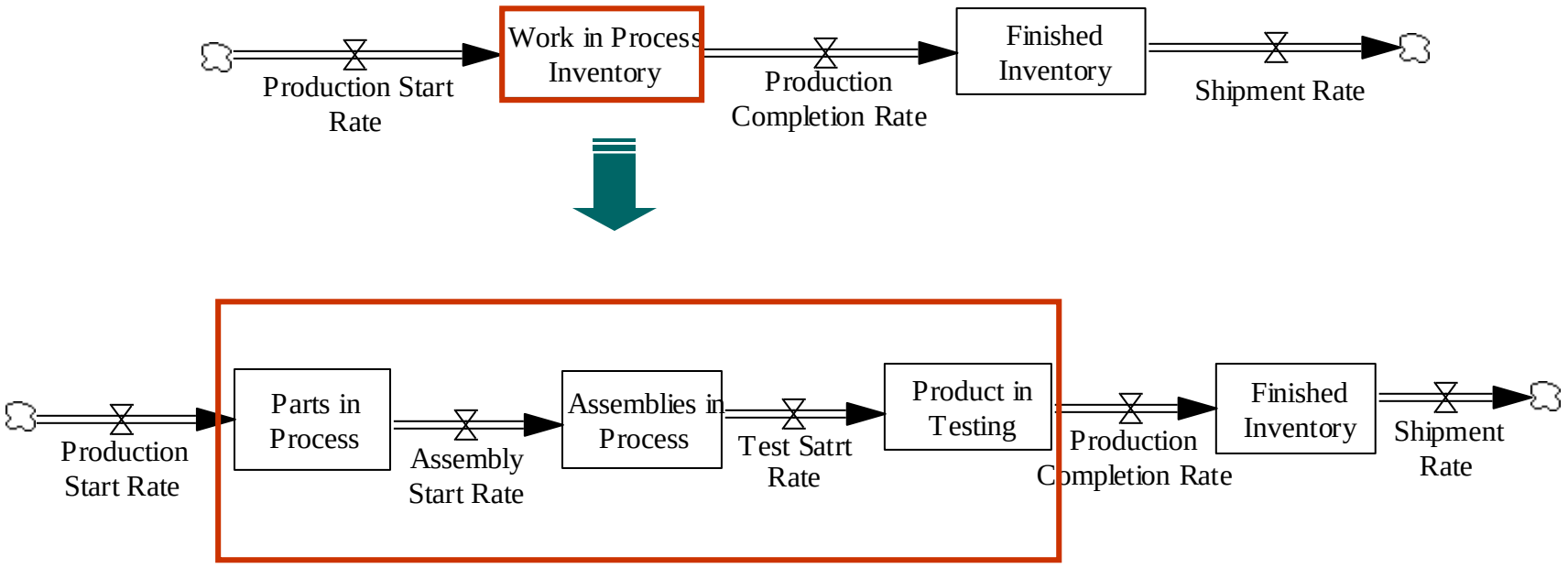


CLD



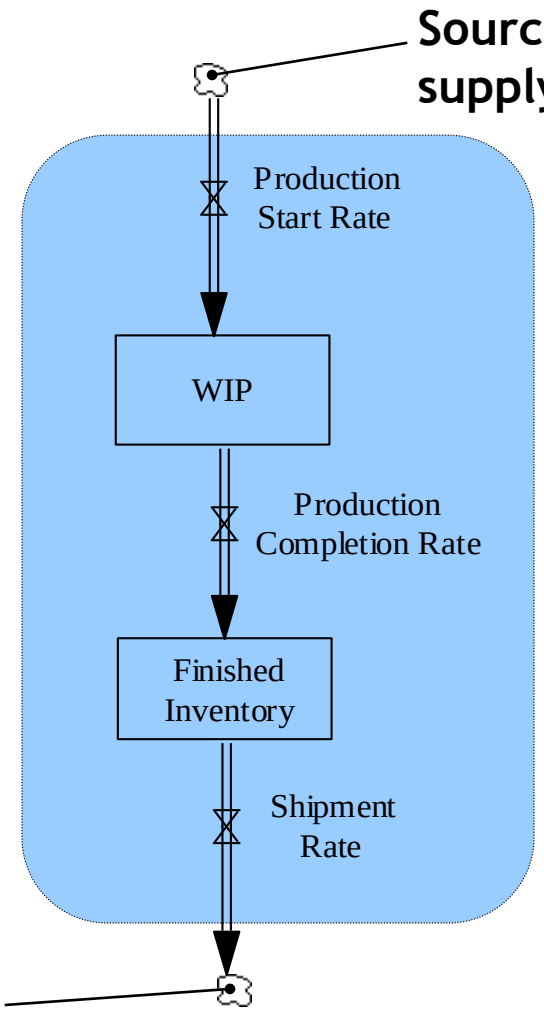
Aggregation & Disaggregation

Appropriate level of aggregation should be decided depending on modeling purposes.



Challenging the clouds

Set the model boundary based on modeling purpose and scope.



Lecture Outline

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Where did the gasoline go?

References

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