All models are wrong, just some are useful

Informed policy making with modelling and simulation based on examples from transportation and healthcare domains.

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Keywords: modelling, simulation, policy making, decision making

Agenda

Part I – Introduction

- What is modelling and simulation?
- Why is it so powerful?
- What can we do with it to support policy-making?
- Main formalisms and characteristics of simulation.

Part II – Interactive live cases

- Examples of several models from transportation and healthcare domains (e.g. traffic jam, emergency department, airport terminal, container terminal,- pandemic) – depending on the time.

1. What is modelling and simulation?

Modelling

- Process of abstraction of an issue
  - Model a problem not a system!
  - Useful to understand
- Includes uncertainty expressed with stochasticity
- Input/Output system

Simulation

- Computer-performed execution of a model to predict the outcome/behaviour
- Time-based
- Causal

2. Why is it so powerful?

- Causality
  - In many cases better than ML/AI as it allows to introduce new interventions
- Creates an overview of the system/problem
  - Visualisation via animation/graphics
- Analysing before implementing changes
  - Harness the complexity
  - Understand the gains or risks
- Digital copy can be maintained rather easily
- Often can be reused for similar problems

3. What can we do with it to support policy-making?

- Decision support models (impact assessment)
- What-if analysis
  - Scenario planning
- Digital twins
  - Exploratory/prototyping
- Impartial round-table tool in multi-stakeholder settings
  - Model mechanisms and simulate together
- Multi-objective optimisation
  - Trade-off scenarios
- Education and training

4. Main formalisms and characteristics of simulation.

System Dynamics – using sets of integral equations (stocks and flows) with feedback loops and continuous time

Best to imagine water flow in a complex network of containers

Discrete-event Simulation – system operation is characterised by chronological sequence of events when state transition happen.

Entities travel through a network of queues and processors, often with a central controller.

Agent-Based Simulation – independent agents equipped with own „behaviours" interact with the environment and each other

Emergent system behaviour is obtained by the sum of individual agent decisions + social interactions

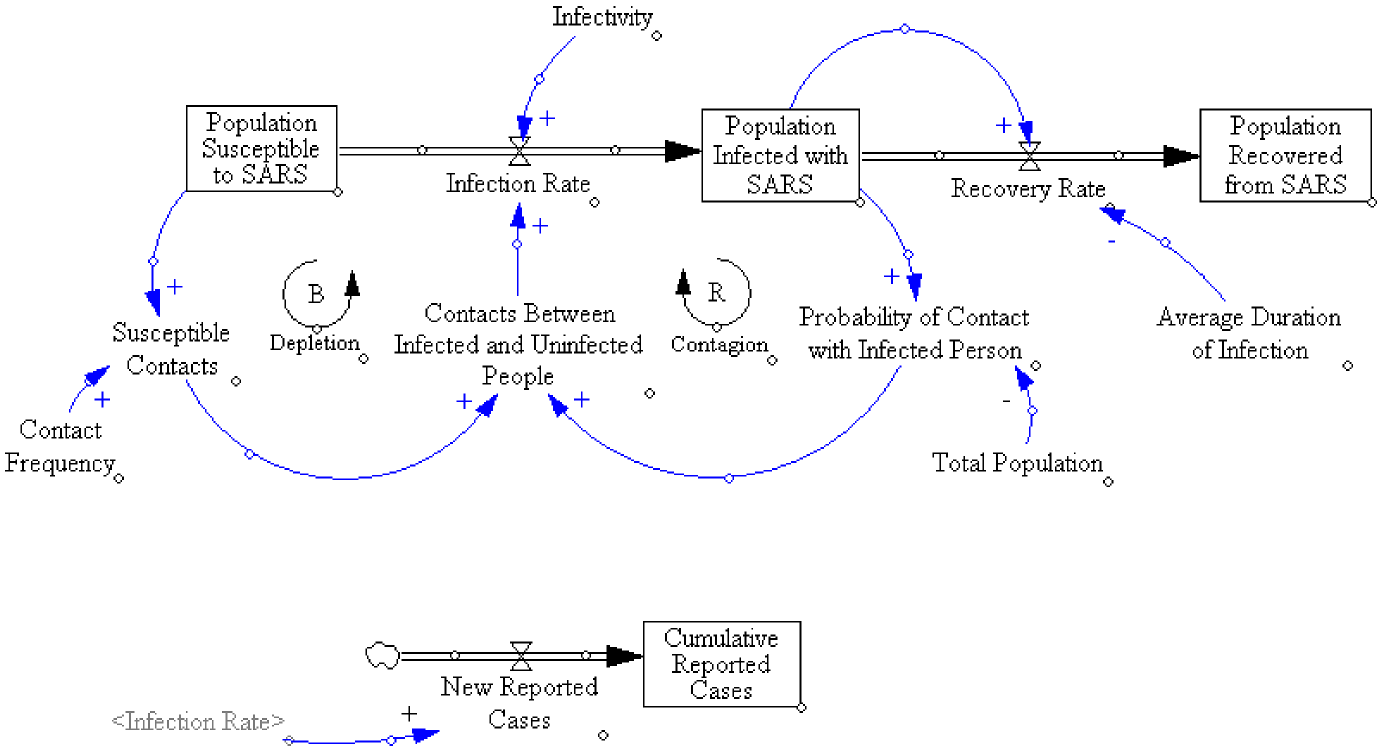
Part II

Interactive live cases

Example 1. – Epidemic!

System dynamics

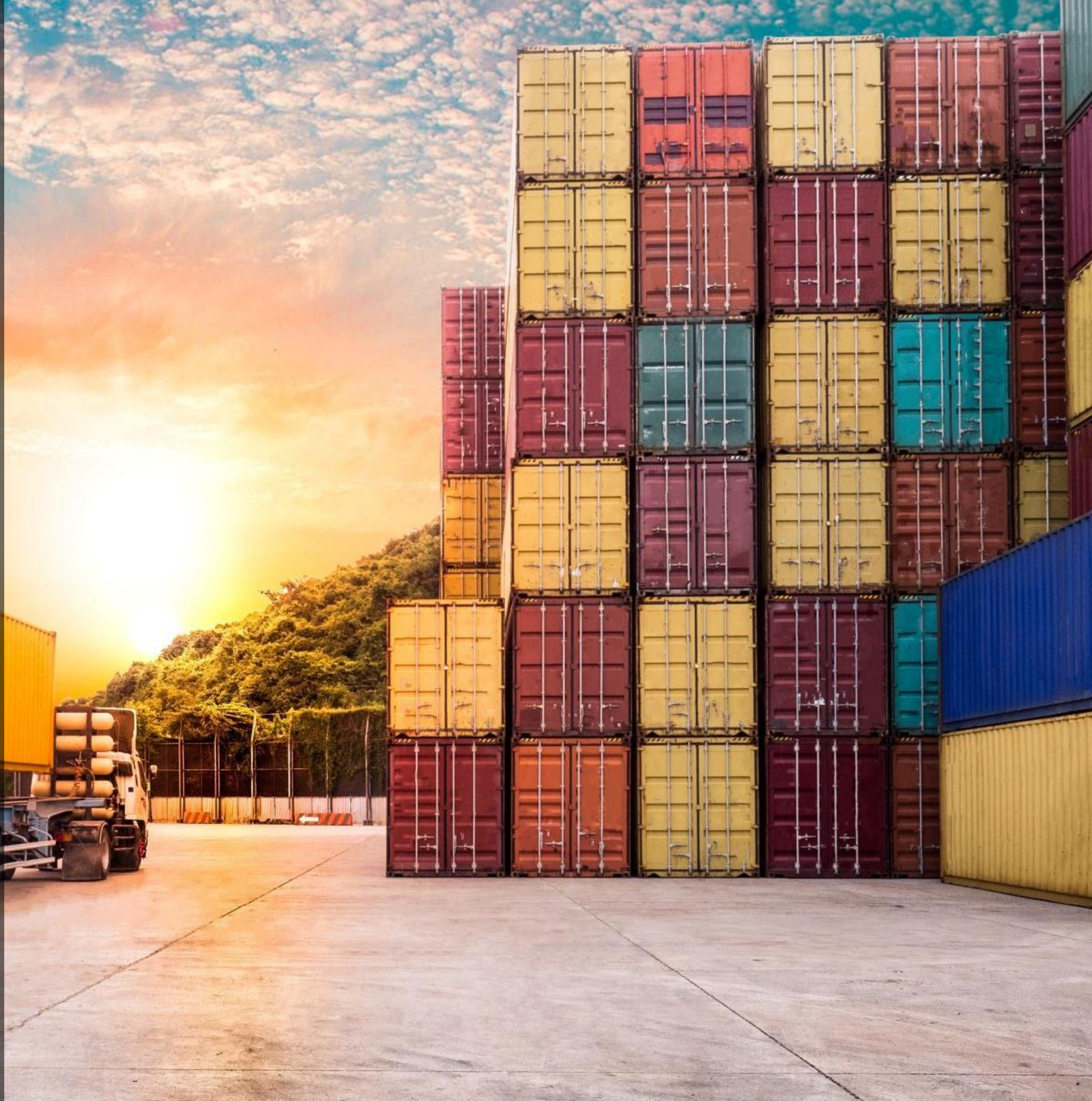
- Often used for policy-making models
- Relatively simplest to make
- Most frequently these are population models: pandemic, adoption, economic



Example 2. – Container terminal simulation

Discrete-event simulation:

- Most frequently used: hospitals, network simulators (transportation and logistics), factory, Design/capacity investigation
- Queue-based system
- Stochastic



Example 3. – Simple traffic jam

Agent-based simulation

- Agents react to neighbouring/linked other agents and the environment
- Via individual actions a whole system’s behaviour emerges
- Most growing formalism: epidemiology, behavioural analytics, economics & social sciences

Example 4. – Hospital emergency room

Discrete-event simulation

Example 5. – Advanced pandemic model

Agent-based simulation