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# Using System Dynamics to explore complex social problems

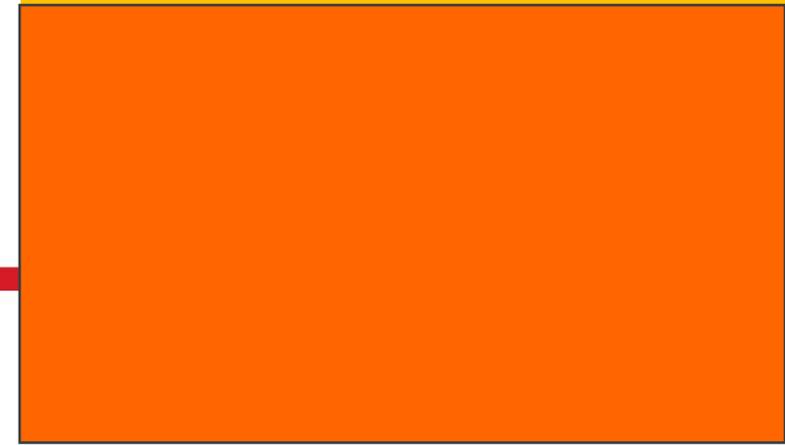
Hugo Herrera

*NWORG Nov 2020*



# Housekeeping

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- We recommend you position the speaker in the top right corner (orange box) so you can see all the slides
- The session will include time for Q&A's after the presentation
- Please, use chat function to submit your questions



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# Using System Dynamics to explore complex social problems

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# OUTLINE

1. Aims for today
2. The challenges of public policy for social problems
3. Introduction to System Dynamics
4. An Example: Welfare reform in the US
5. Interesting resources

## 1. Aims of today

- Introduce you to System Dynamics modelling and analysis method.
- Discuss how System Dynamics can be used in the policy-making world to analyse complex social issues.
- Show an example showing how Systems Dynamics was used to understand these problems.

## 2. The challenges of public policy for social problems

## SOCIAL PROBLEM

*A social problem* is any condition or behaviour that has negative consequences for large numbers of people and that is generally recognized as a condition or behaviour that needs to be addressed.



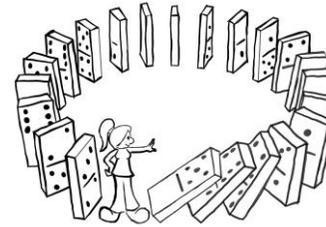
# THE CHALLENGES OF PUBLIC POLICY FOR SOCIAL PROBLEMS



- *Need to persuade different stakeholders*
- *Policy resistance from the environment*
- *Overconfident policymakers*

Policymaking is not a straightforward process in which a decision maker decides, and others immediately implement. Rather, different constituencies, pressure groups and stakeholders in and outside of government all play important roles in developing policies and influencing their effectiveness throughout society.

# THE CHALLENGES OF PUBLIC POLICY FOR SOCIAL PROBLEMS



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If system complexity is overlooked, policy actions trigger feedback from the system that undermine the policy and at times even exacerbates the original problem. For example, when police forces are deployed to control an illegal drug market, drug supply decreases, leading to higher drug prices, more profit per sale, and greater attractiveness of drug dealing. The number of dealers increases, undermining the original policy.

# THE CHALLENGES OF PUBLIC POLICY FOR SOCIAL PROBLEMS



- *Need to persuade different stakeholders*
- *Policy resistance from the environment*
- *Overconfident policymakers*

Overconfidence among decision makers is widely documented in the psychology and decision science. Individuals tend to be overconfident in their decisions when dealing with moderate or extremely difficult questions, expressing 90 percent subjective confidence intervals that in fact only contain the true value about 30–60 percent of the time.

# THE CHALLENGES OF PUBLIC POLICY FOR SOCIAL PROBLEMS

*We need a tool that helps us to:*

- *communicate and negotiate*
- *assess complexity*
- *provides transparent factual base advice*

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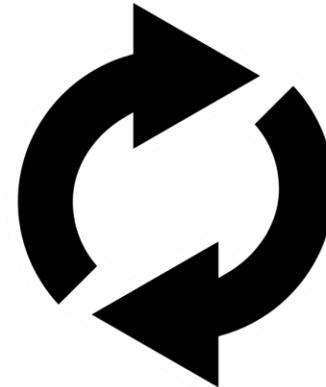
*System Dynamics:*

- *simple and transparent*
- *focus on complexity*
- *aggregated*

# 3. Introduction to System Dynamics

# WHAT IS SYSTEM DYNAMICS

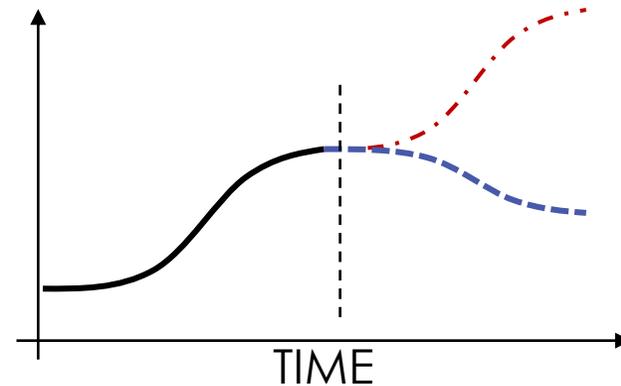
System Dynamics is a modelling method focused on studying how outcomes of the systems are driven by system's own internal mechanisms. System Dynamics focuses on understanding the **circular relationships (feedback loops)** driving the outcomes of the system.<sup>1</sup>



<sup>1</sup>Richardson, G. P. (2011). Reflections on the foundations of system dynamics. *System Dynamics Review*, 27(3), 219-243.

# WHAT IS SYSTEM DYNAMICS

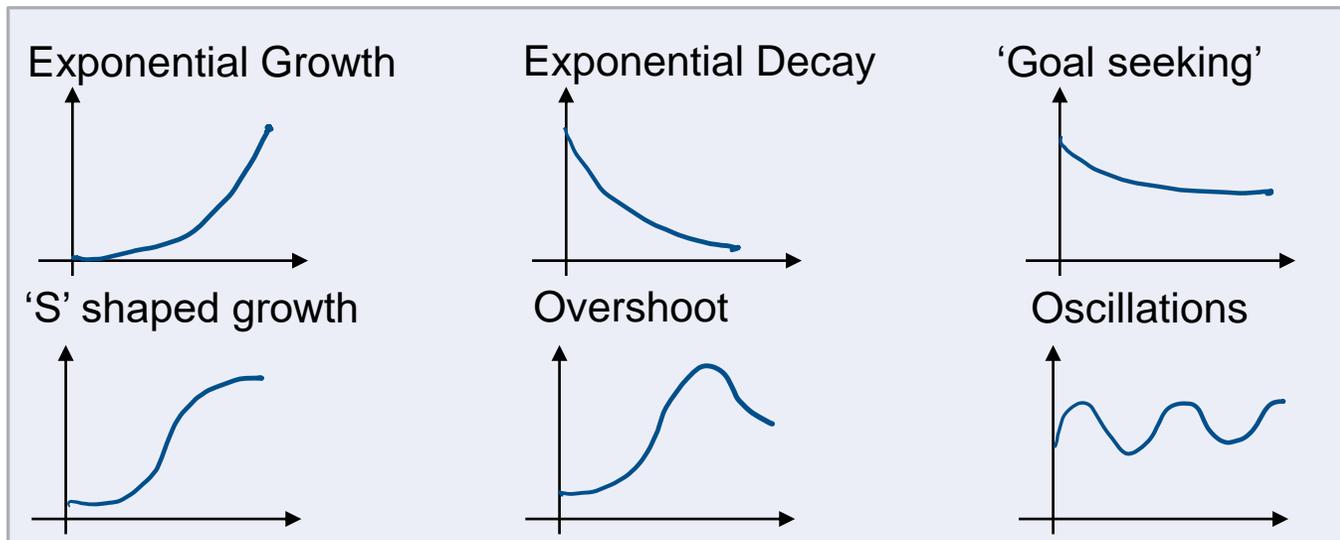
System dynamics is a method of analysing problems in which **time is an important factor**, and which involves the study of how a system can be defended against, or made to benefit from, the shocks which foil upon it from the outside world.<sup>2</sup>



<sup>2</sup>Coyle, R. G. (1977). *Management system dynamics* (No. 04; HD20. 5, C6.).

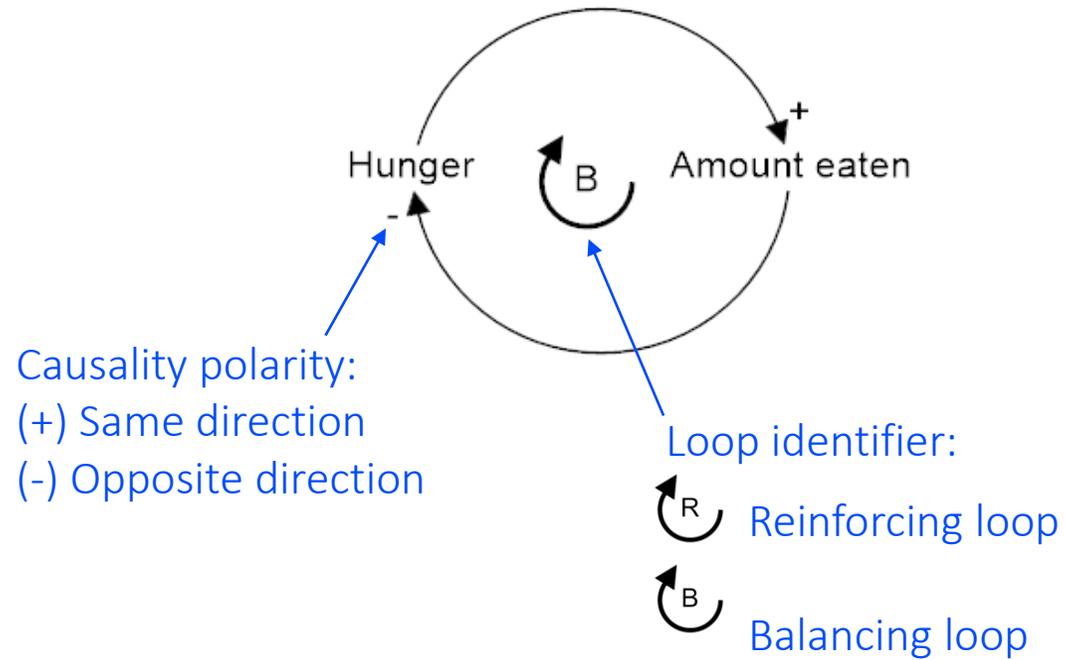
# THE DYNAMICS OF SYSTEM DYNAMICS

The "dynamics" in system dynamics are the fundamental patterns of change, such as growth, decay, and oscillations. System dynamics models are constructed to help us understand why these general patterns occur.<sup>3</sup>



<sup>3</sup>Ford, A., & Ford, F. A. (1999). Modeling the environment: an introduction to system dynamics models of environmental systems. Island press.

# LOOPS AND NOMENCLATURE



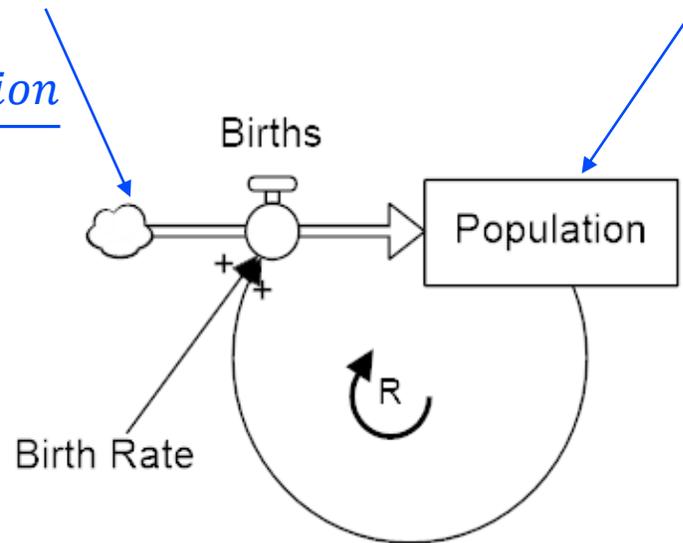
# STOCKS AND FLOWS

**Flows:** variables that affect stocks. Examples: births, waste disposed in a landfill, people getting infected.

**Stocks:** variables that accumulate. Don't change instantaneously. Examples: population, waste in a landfill, number of people infected.

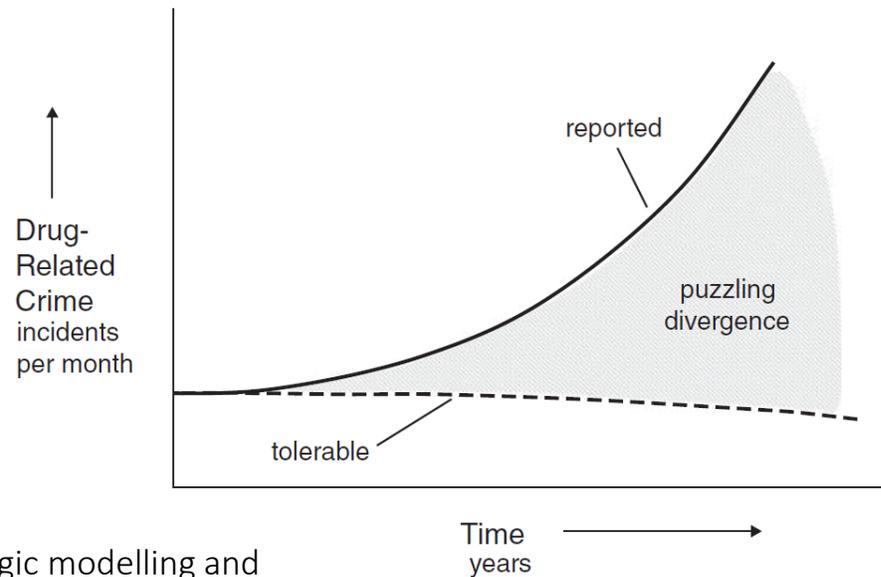
$$Births = \frac{dPopulation}{d\ time}$$

$$\int_{t=0}^{t=x} Births\ dt$$



## LET'S BUILD OUR FIRST MODEL

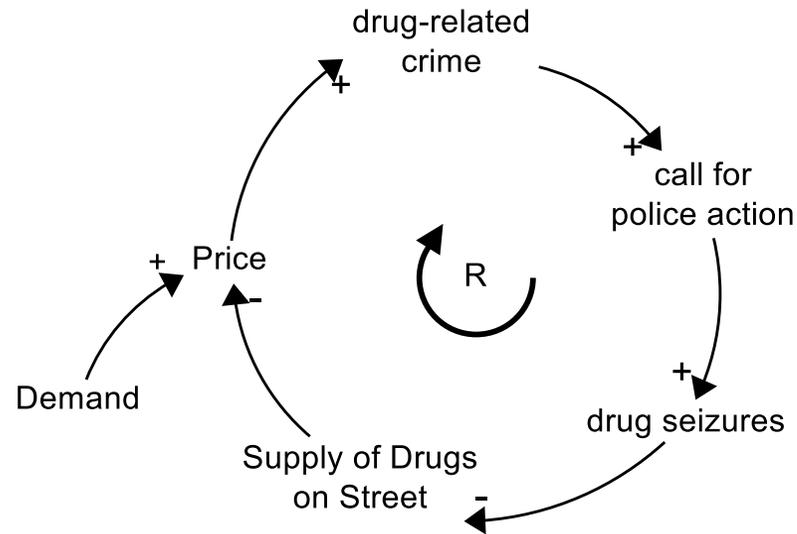
*“Drugs are a big worry for me, not least because of the crimes that addicts commit to fund their dependency. We want the police to bust these rings and destroy the drugs. They say they’re doing it and they keep showing us sacks of cocaine that they’ve seized, but the crime problem seems to be getting worse.”*



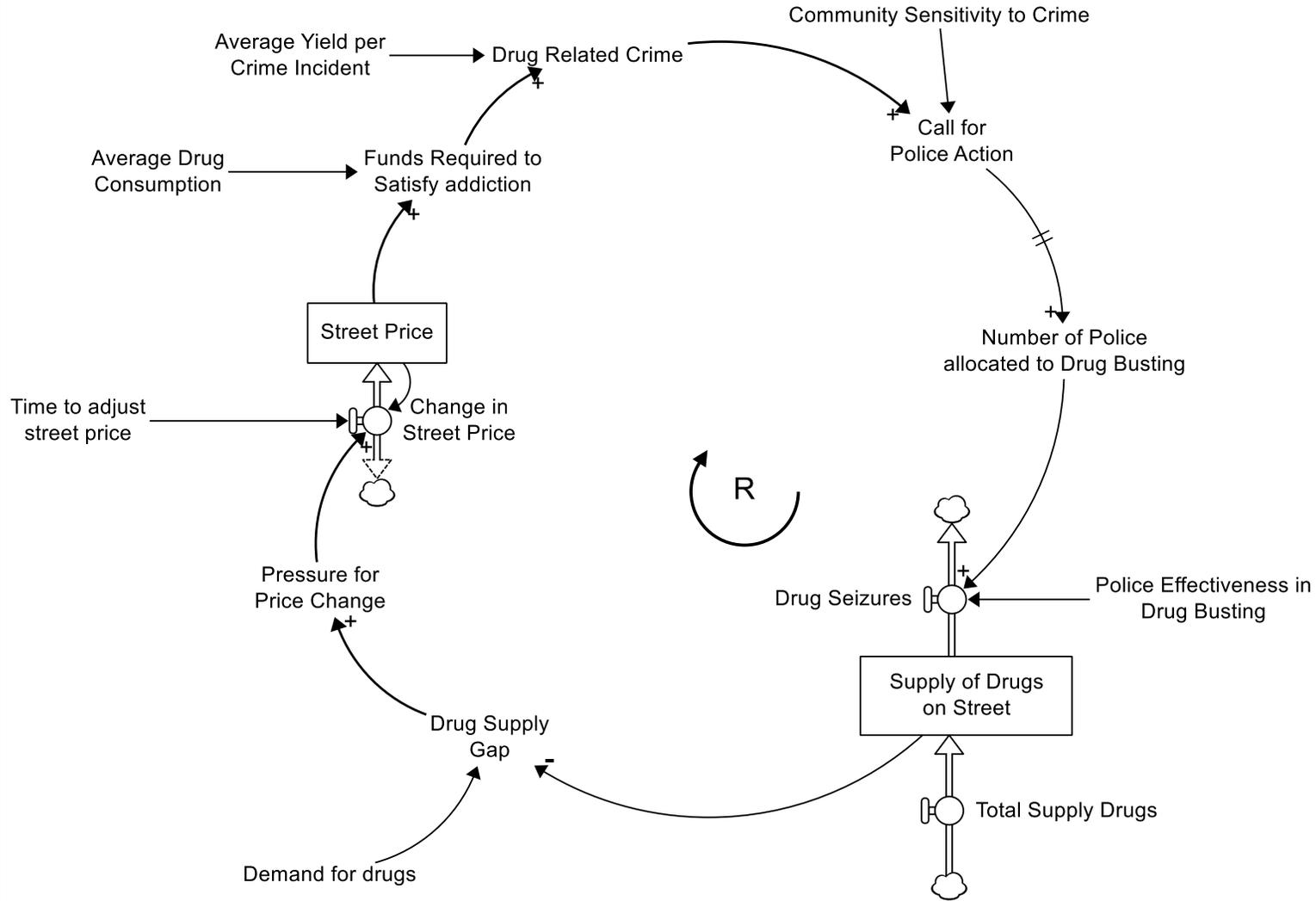
Adapted from: Morecroft, J. D. (2015). Strategic modelling and business dynamics: A feedback systems approach. John Wiley & Sons.

## LET'S BUILD OUR FIRST MODEL

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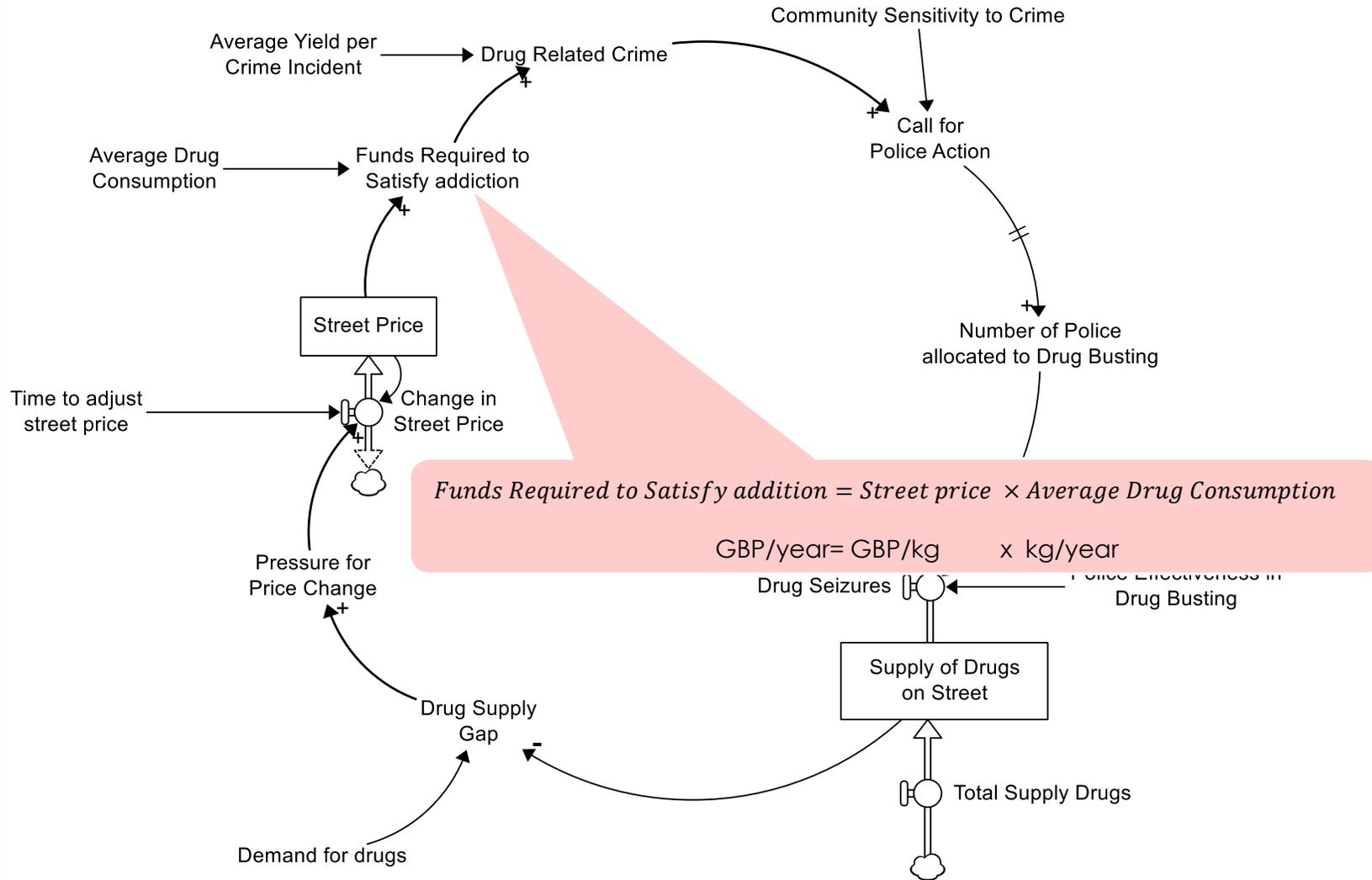


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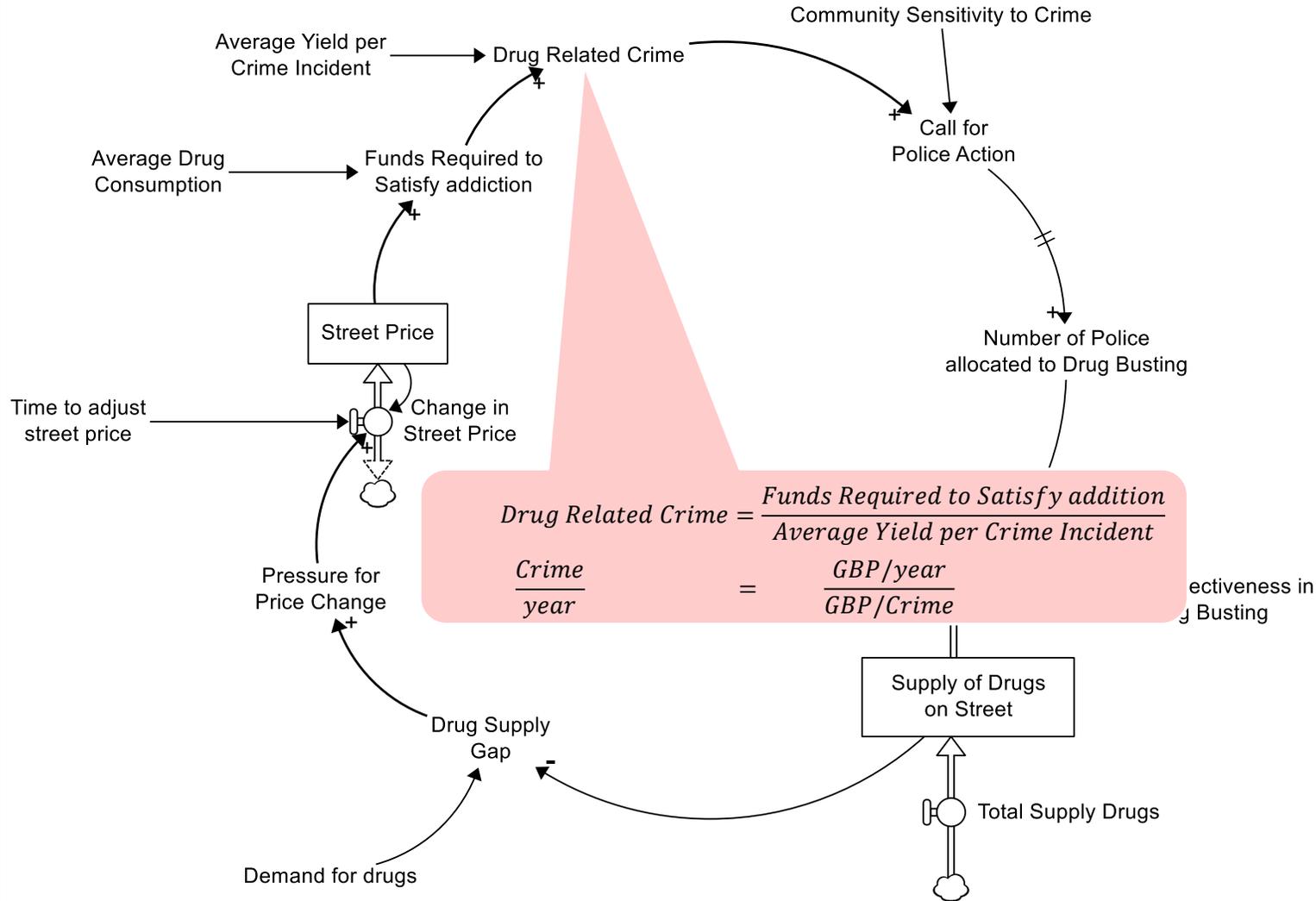
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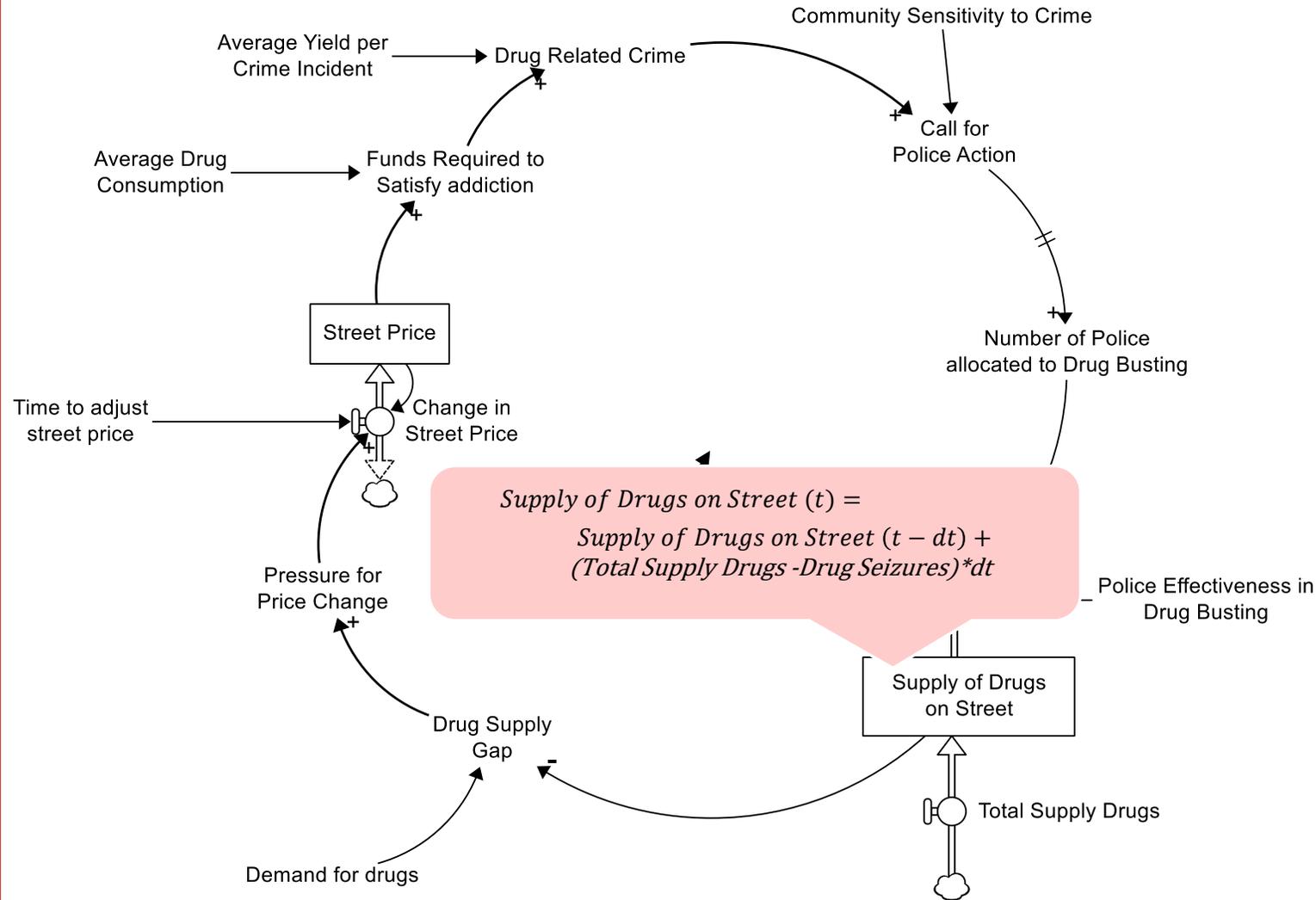
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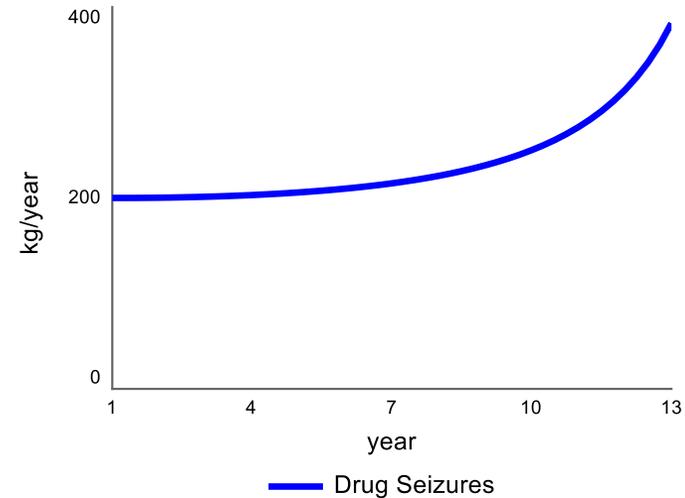
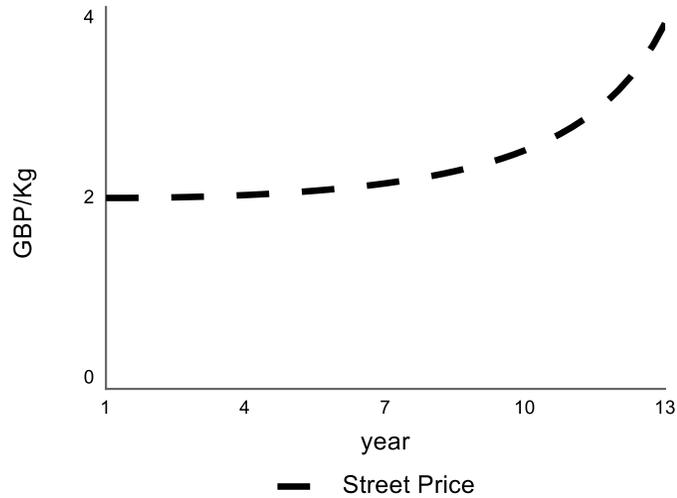
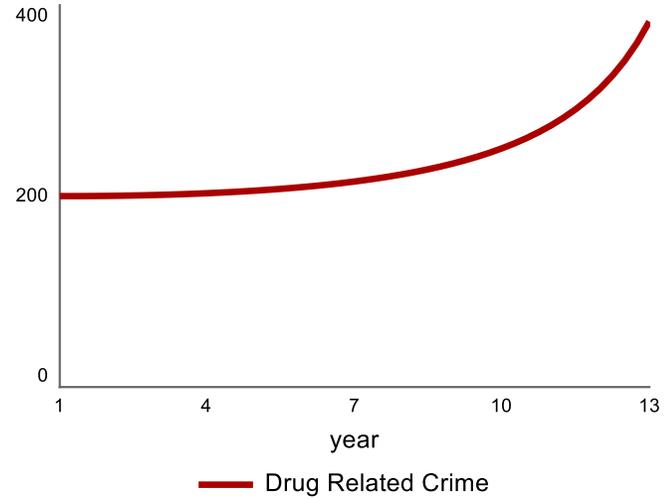
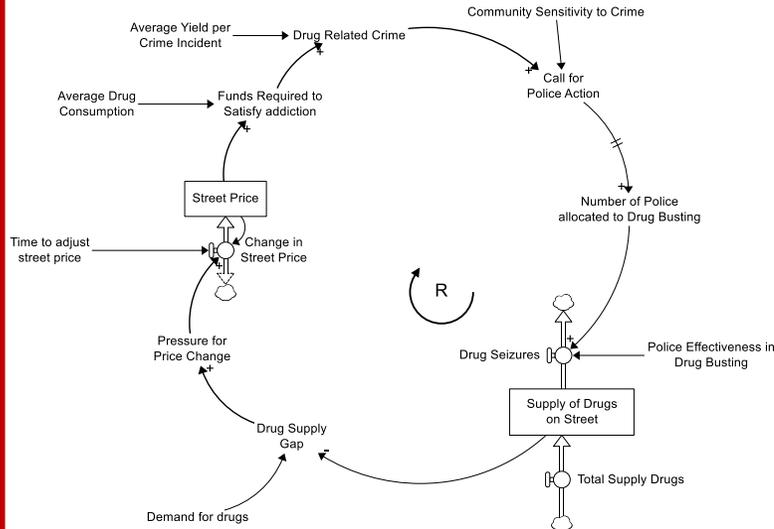
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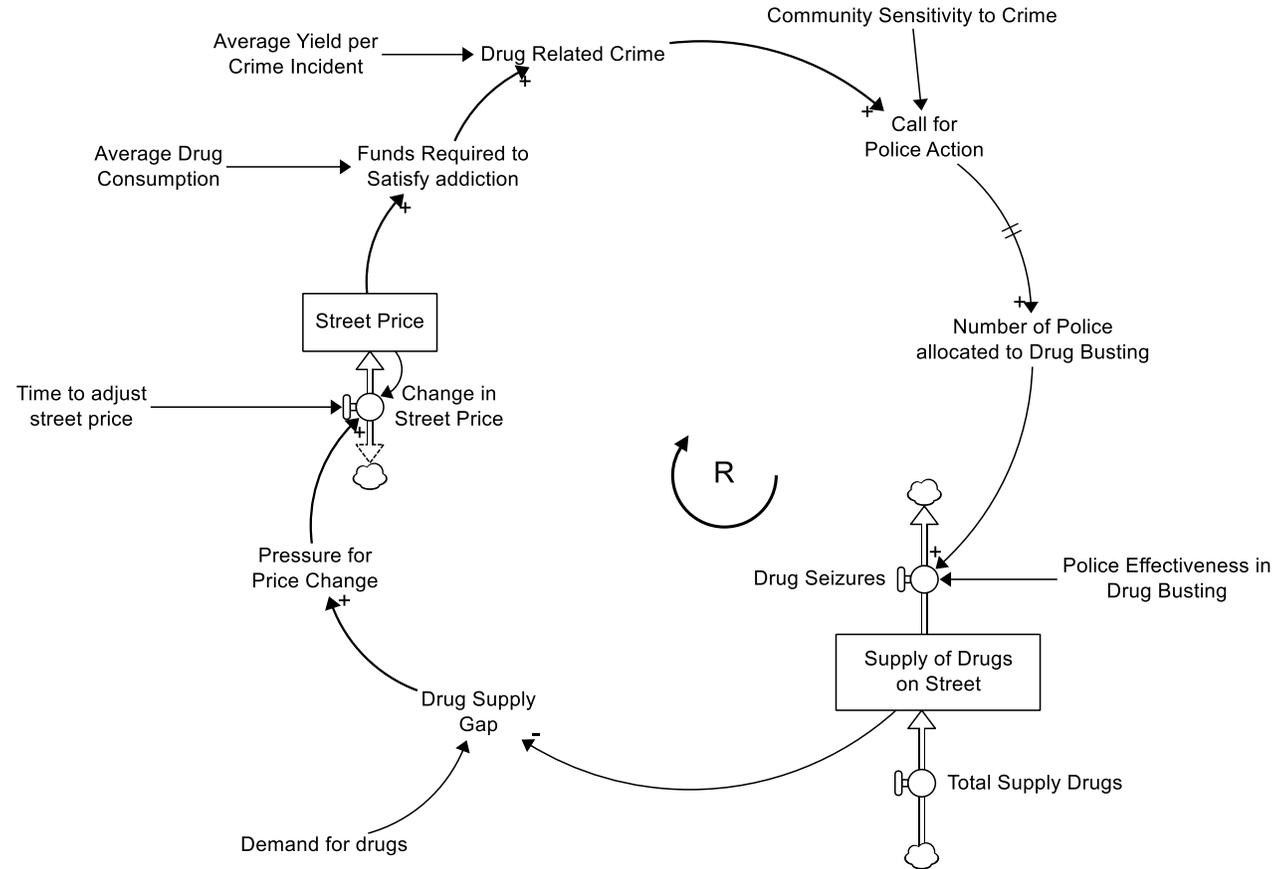
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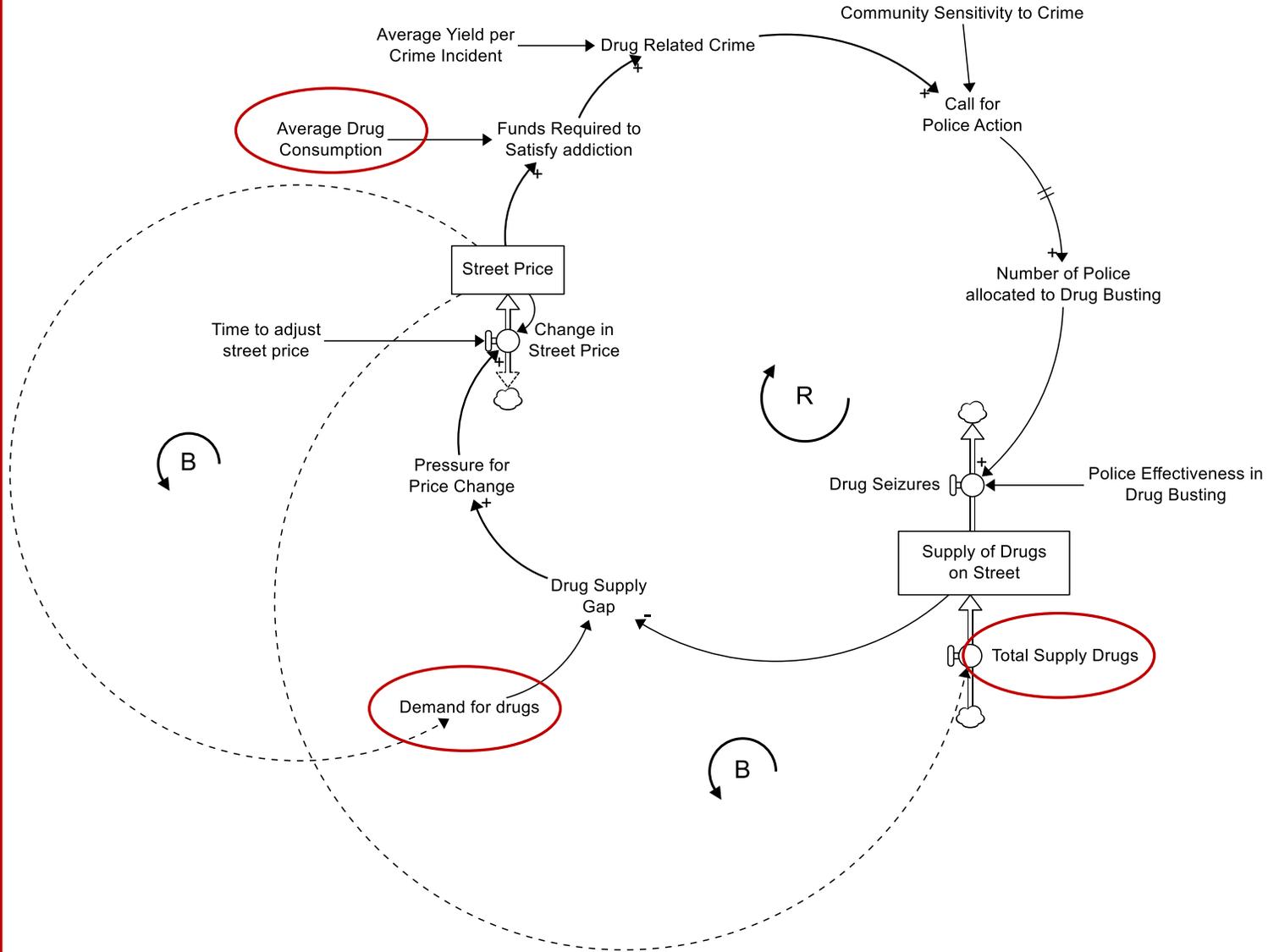


Let's build our first model

# Let's build our first model



# Let's build our first model



## 4. An Example: Welfare reform in the US

# WELFARE REFORM

Cortland county, US

In 1996, the Clinton Administration reformed the US welfare system with the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA), which created the Temporary Assistance for Needy Families (TANF) programme.



Using group model building to inform welfare reform policy making in New York State: a critical look.  
Proceedings of the 2003 International Conference of the System Dynamics Society. New York City (July 20-24).

# WELFARE REFORM

## Cortland county, US

The TANF program, which is time limited, assists families with children when the parents or other responsible relatives cannot provide for the family's basic needs. The Federal government provides grants to States to run the TANF program. These State TANF programs are designed to accomplish four goals:

- to **provide assistance** to needy families so that children may be cared for in their own homes or in the homes of relatives;
- to end the dependency of needy parents on government benefits by promoting **job preparation**,
- to prevent and **reduce the incidence of out-of-wedlock pregnancies** and establish annual numerical goals for preventing and reducing the incidence of these pregnancies; and
- to **encourage the formation and maintenance of two-parent families.** <sup>4</sup>



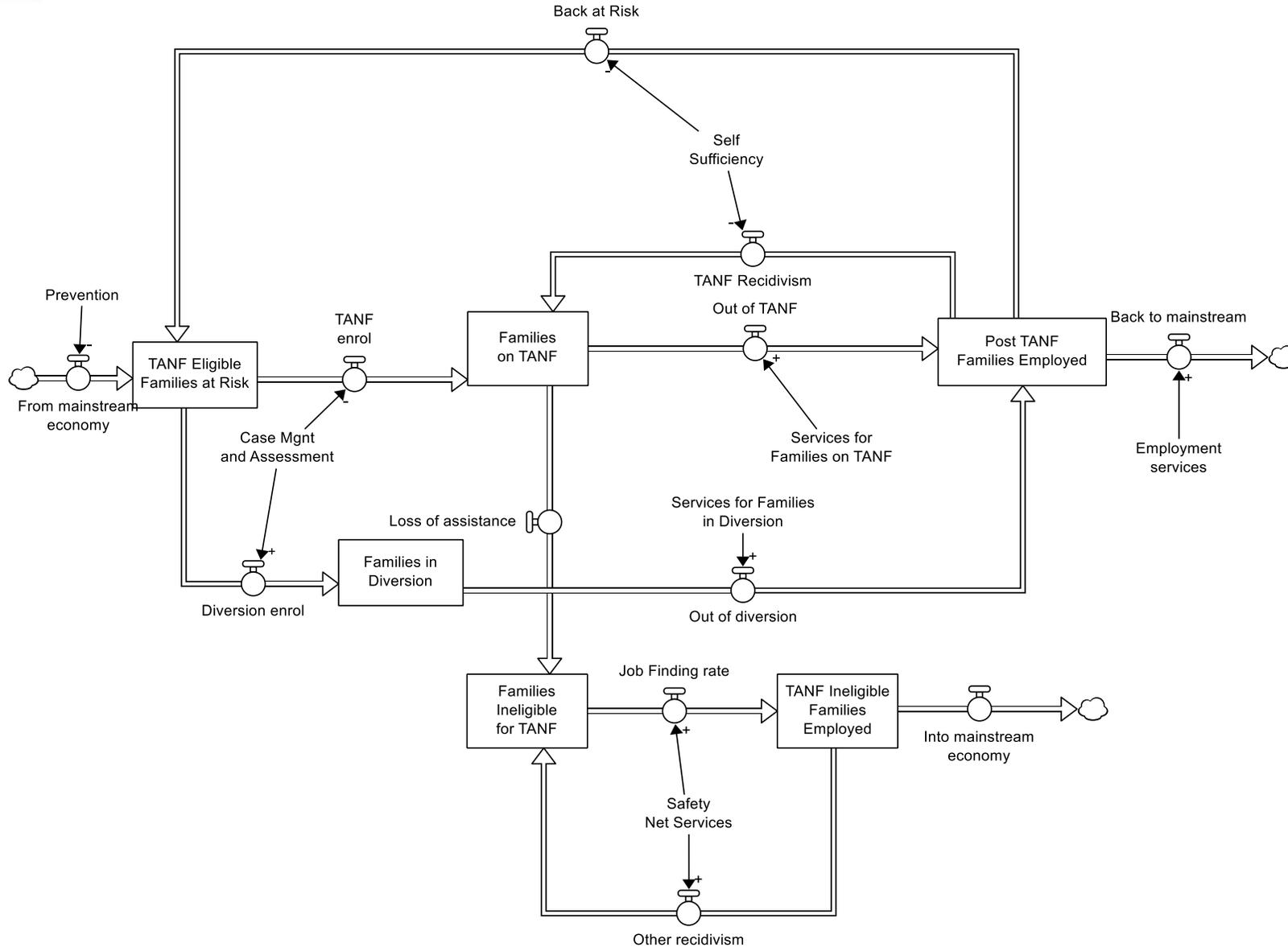
<sup>4</sup><https://www.hhs.gov/answers/programs-for-families-and-children/what-is-tanf/index.html#:~:text=TANF%20stands%20for%20Temporary%20Assistance%20for%20Needy%20Families.,grants%20to%20States%20to%20run%20the%20TANF%20program.>

# WELFARE REFORM

Cortland county, US

In January of 1997, Aldo Zagonel, John Rohrbaugh, George Richardson and David Andersen were involved in a simulation project with a coalition of New York State agencies and three county governments to address state-level policy-making issues in regard to TANF.

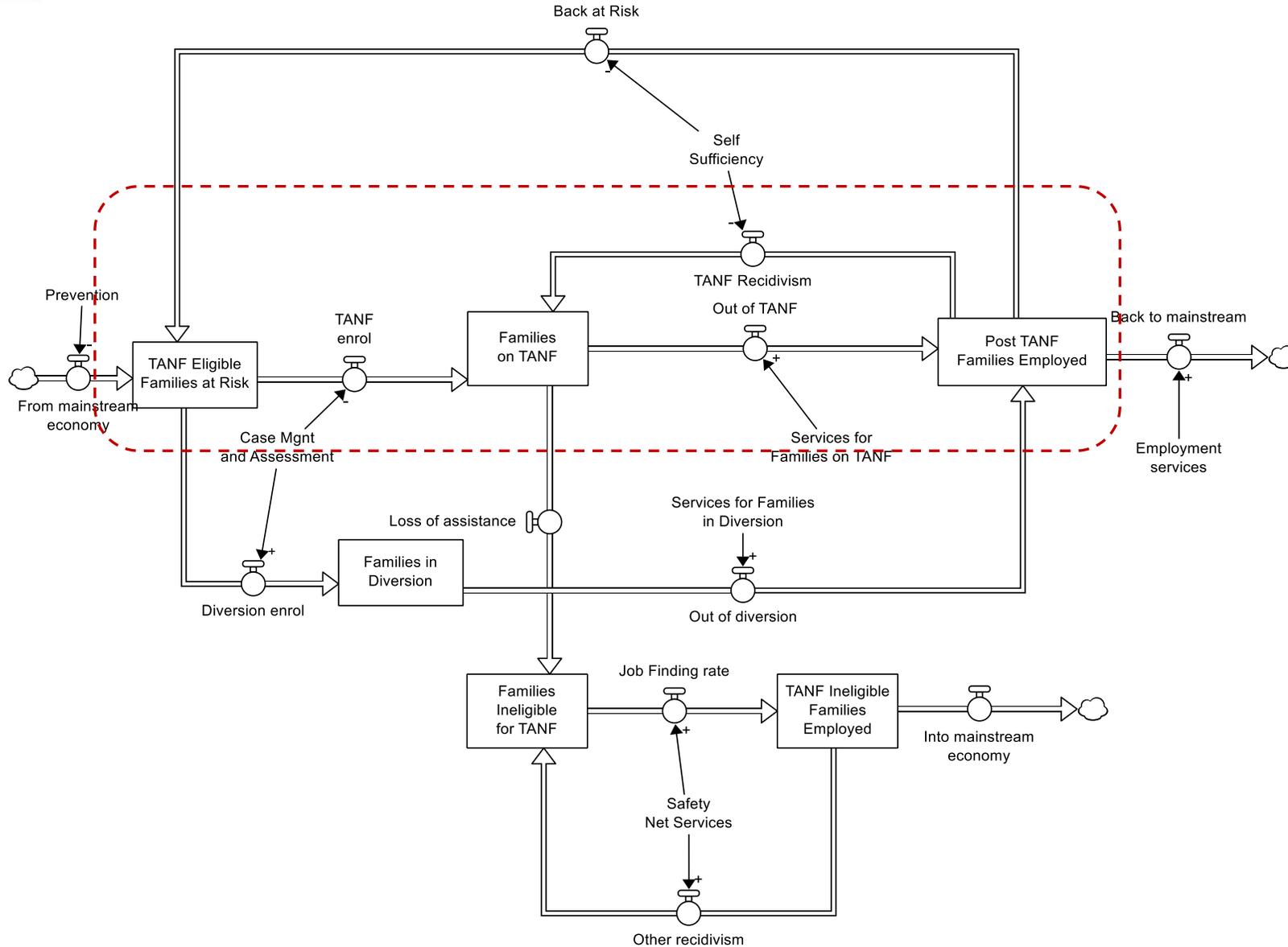




# Welfare reform

## Cortland county, US

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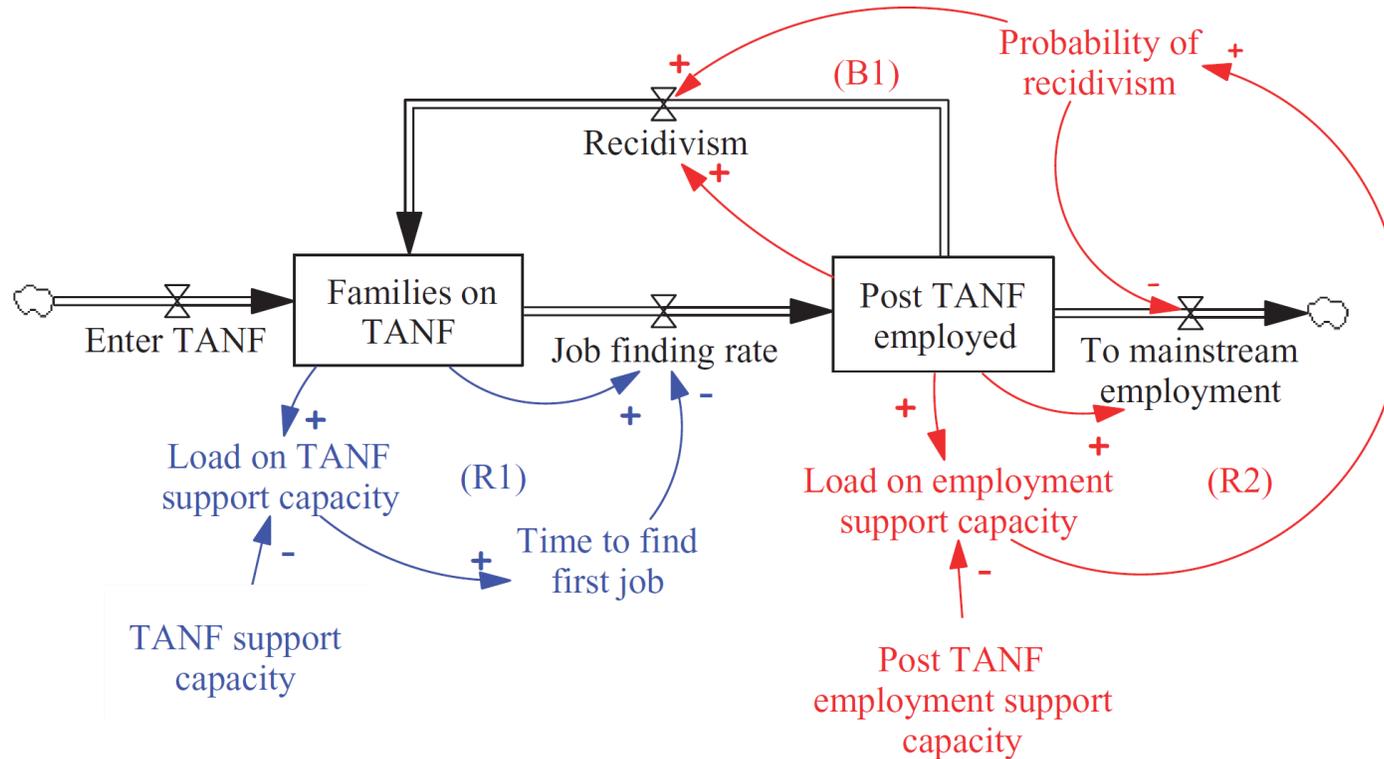


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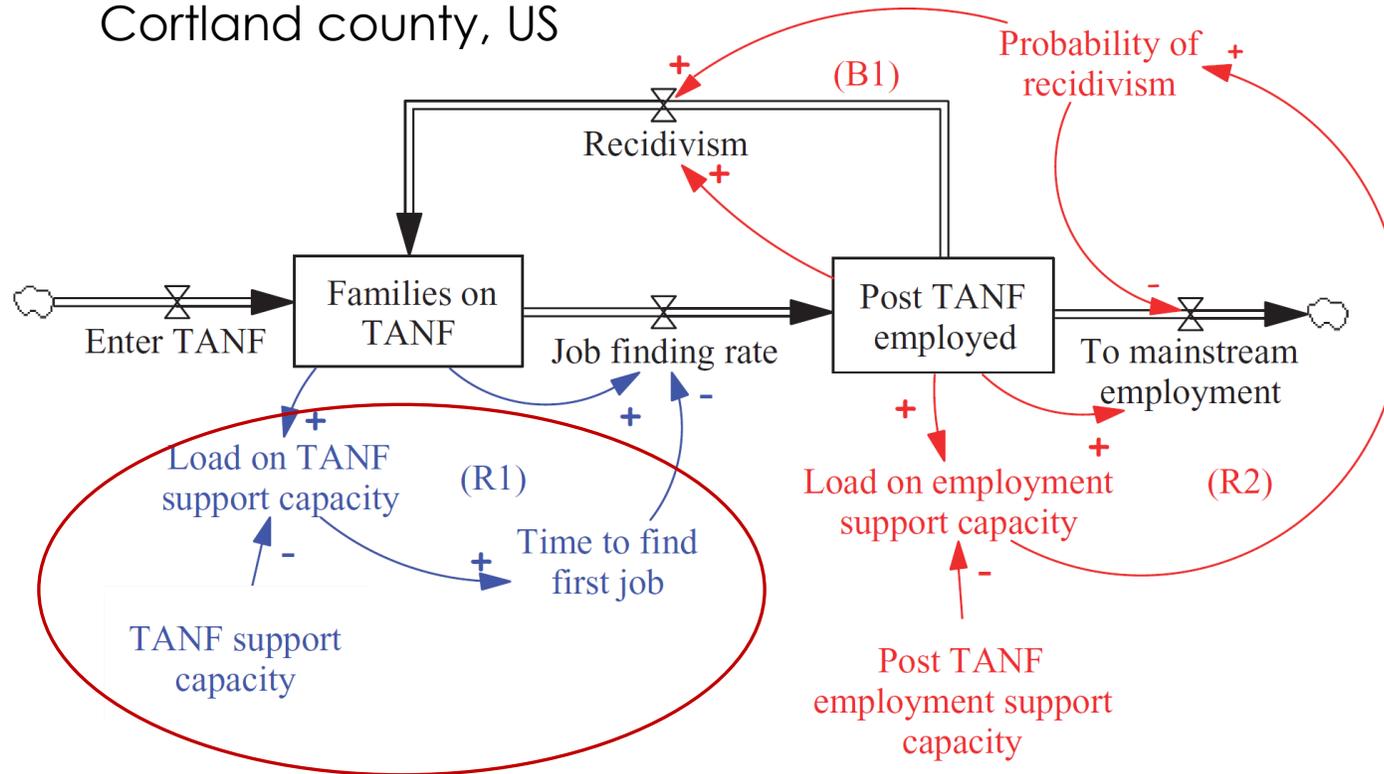
# WELFARE REFORM



Adapted from: Ghaffarzadegan, N., Lyneis, J., & Richardson, G. P. (2011). How small system dynamics models can help the public policy process. *System Dynamics Review*, 27(1), 22-44.

# WELFARE REFORM

Cortland county, US

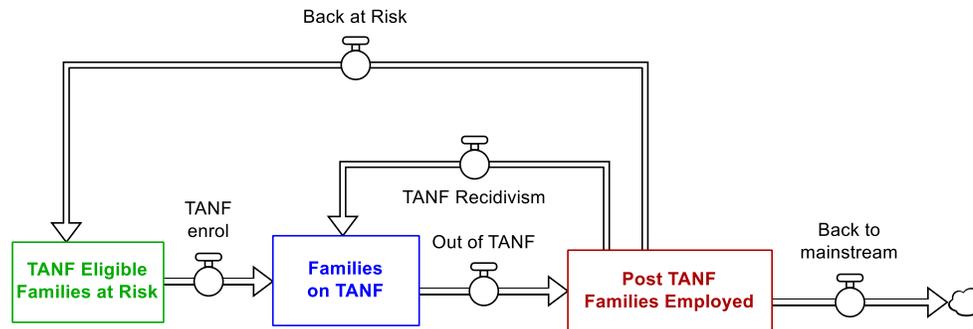
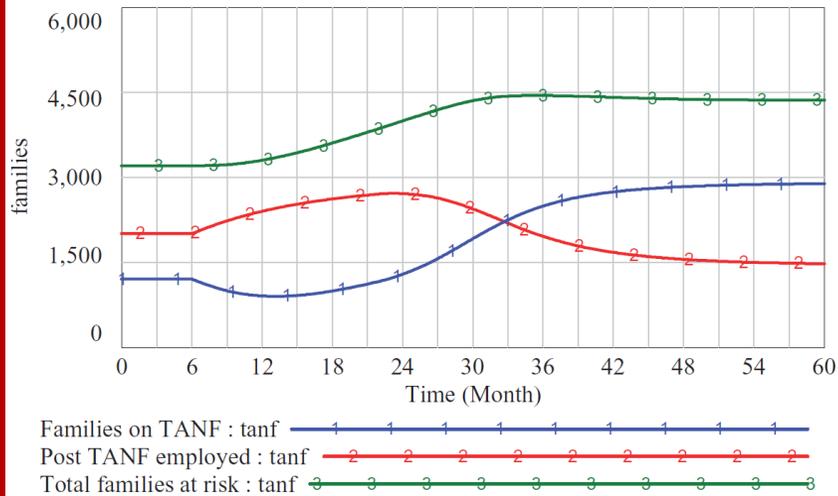


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# WELFARE REFORM

Cortland county, US

At risk populations

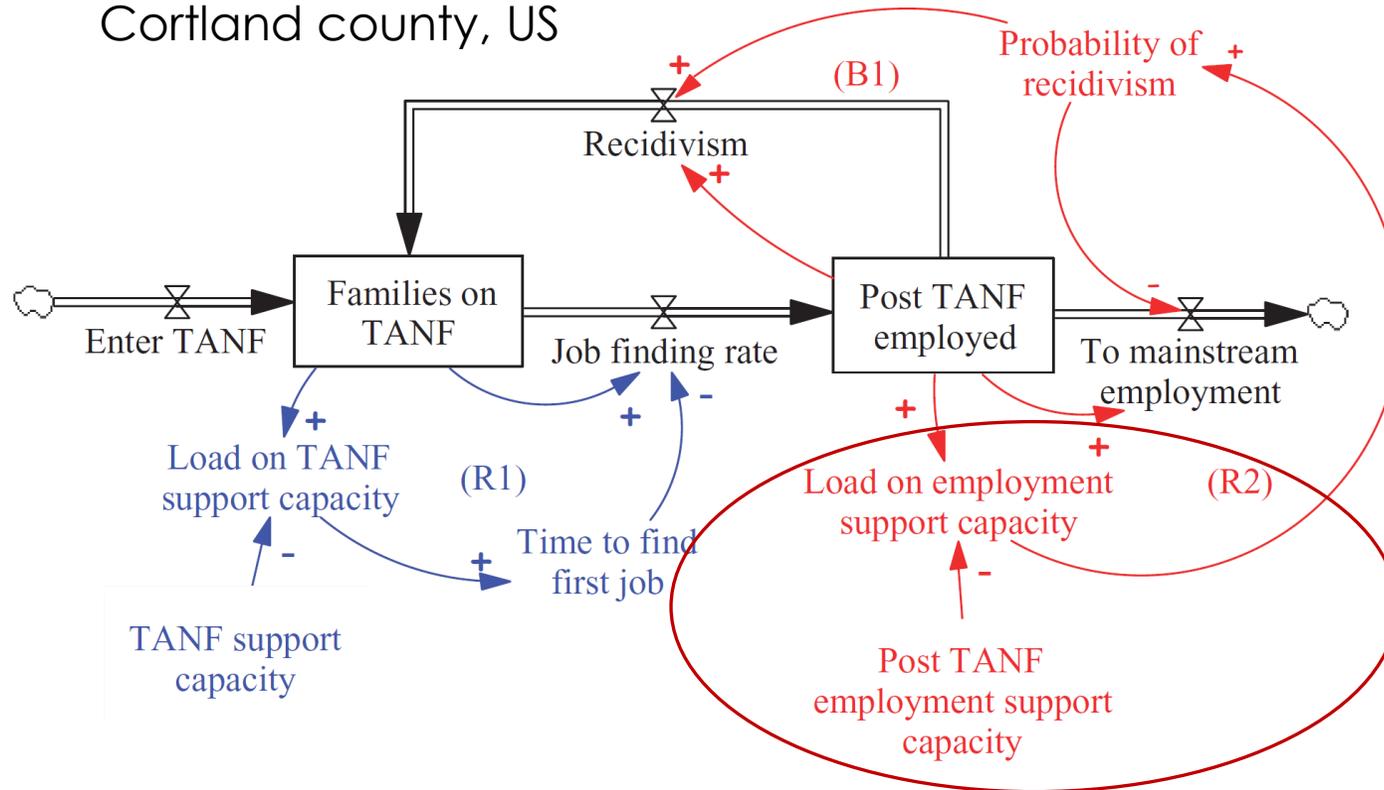


(a) 20% increase in the upstream capacity

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# WELFARE REFORM

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## 5. Interesting resources

- OR society  
([www.theorsociety.com](http://www.theorsociety.com))
- UK System Dynamics Chapter  
([www.systemdynamics.org.uk](http://www.systemdynamics.org.uk))
- System Dynamics Society  
([www.systemdynamics.org](http://www.systemdynamics.org))



- Sterman, J. (2010). *Business dynamics*. Irwin/McGraw-Hill
- Senge, P. M. (2006). *The fifth discipline: The art and practice of the learning organization*.
- Ford, A., & Ford, F. A. (1999). *Modeling the environment: an introduction to system dynamics models of environmental systems*. Island press.
- Morecroft, J. D. (2015). *Strategic modelling and business dynamics: A feedback systems approach*. John Wiley & Sons.



Questions?

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