System Dynamics Applications with Impact

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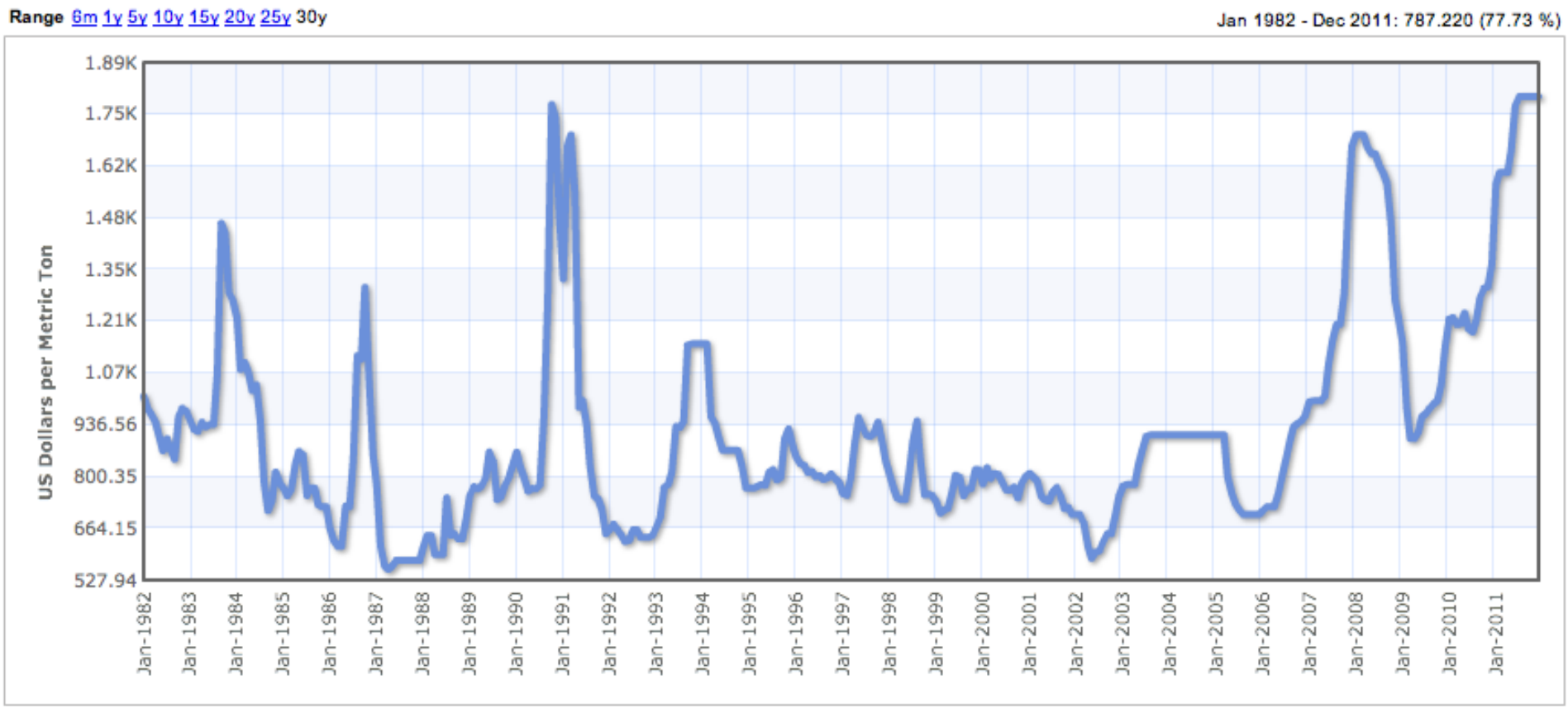
Outline

- Commodity cycles
- Project dynamics
- Urban dynamics
- Epidemics & infectious disease policy
- What generates impact?

Commodity Cycles

(All graphs from
http://www.indexmundi.com/commodities/)

Peanuts (USD/ton), 1982-2012



Description: Groundnuts (peanuts), 40/50 (40 to 50 count per ounce), cif Argentina, US Dollars per Metric Ton

Unit: US Dollars per Metric Ton

GAMBIA: Can peanut farming bounce back?

http://www.irinnews.org/report.aspx?reportid=83773

Photo: Nicholas Reader/IRIN

Groundnuts are Gambia's biggest cash crop, bringing in 43 percent of agricultural revenues and 13 percent of overall income, according to Bakary Trawally, permanent secretary of the Department of State for Agriculture.

Aluminum (USD/ton) 1982-2012

Description: Aluminum, 99.5% minimum purity, LME spot price, CIF UK ports, US Dollars per Metric Ton

Unit: US Dollars per Metric Ton

Phillipines:
Artisanal mining compounds landslide risk

http://www.irinnews.org/report.aspx?reportid=94629

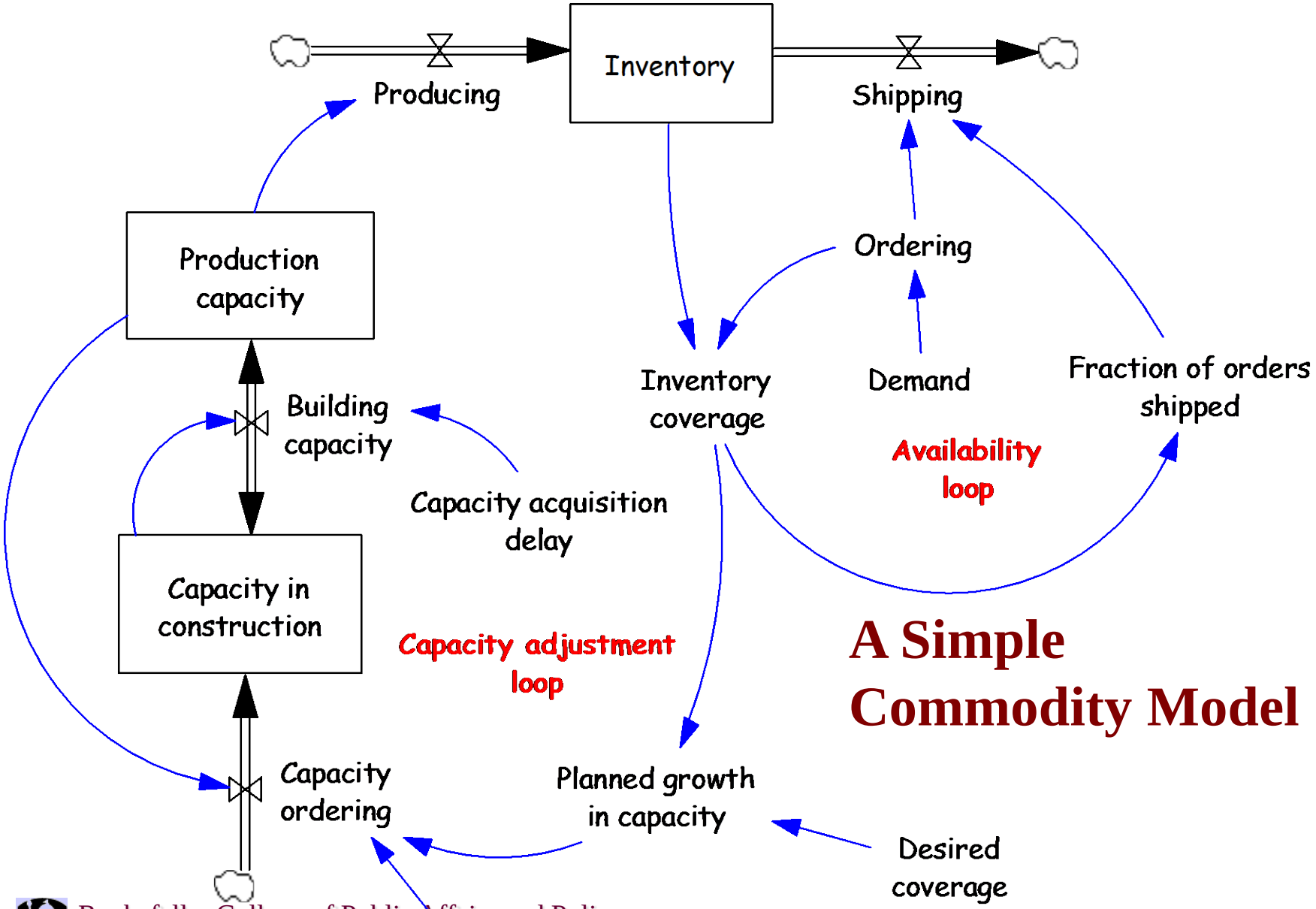
MANILA, 12 January 2012 (IRIN) - A deadly landslide in the southern Philippines in early January underscores the dangers of unregulated, artisanal mining, experts say.

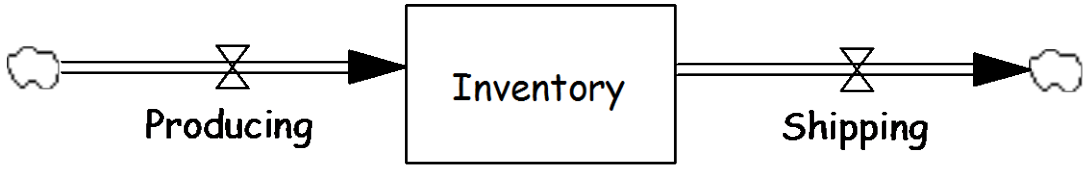
According to the World Bank, an estimated 20 million men, women and children worldwide from over 50 developing countries are engaged in artisanal and small-scale mining, while a further 100 million depend on it for their livelihoods.

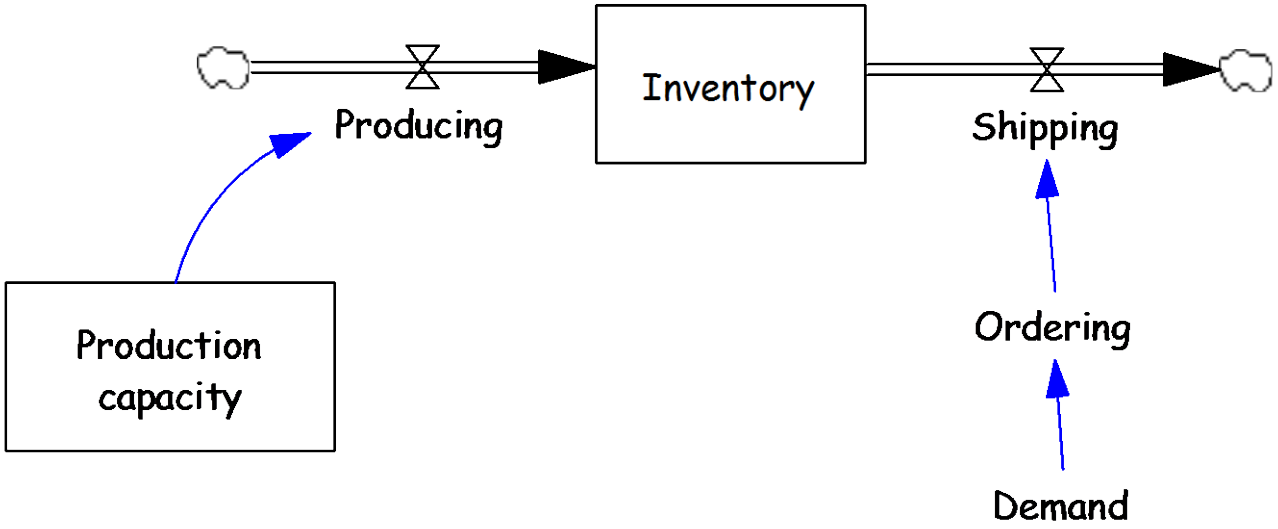
Coffee Price (US cents/pound) 1982-2012

Description: Coffee, Other Mild Arabicas, International Coffee Organization New York cash price, ex-dock New York, US cents per Pound

Unit: US cents per Pound


Inventory
Producing
Shipping
Production capacity
Ordering
Building capacity
Inventory coverage
Demand
Fraction of orders shipped
Availability loop
Capacity acquisition delay
Capacity in construction
Capacity adjustment loop
A Simple Commodity Model
Capacity ordering
Planned growth in capacity
Desired coverage
Planning time


Producing
Inventory
Shipping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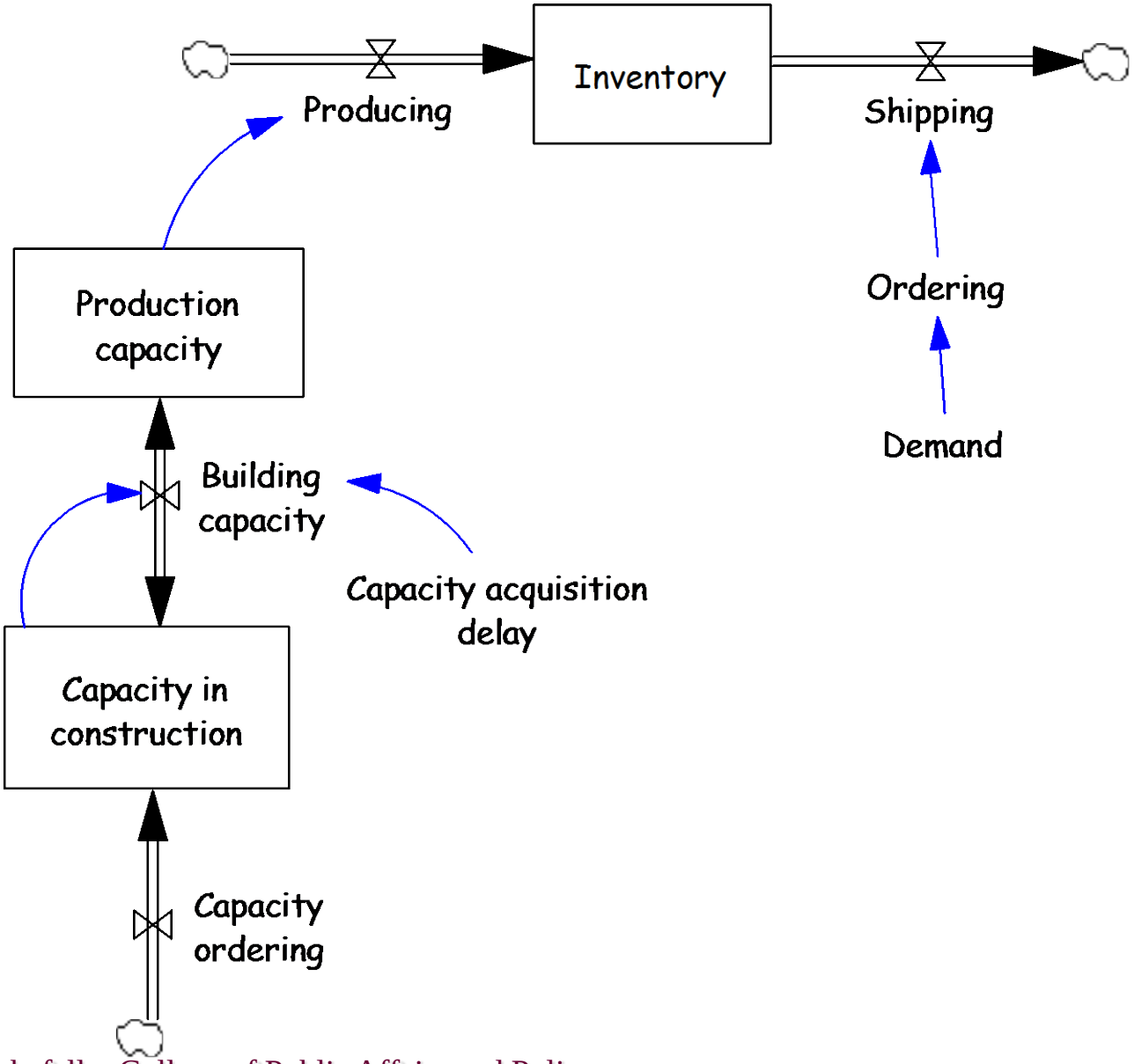
Production capacity
Ordering
Demand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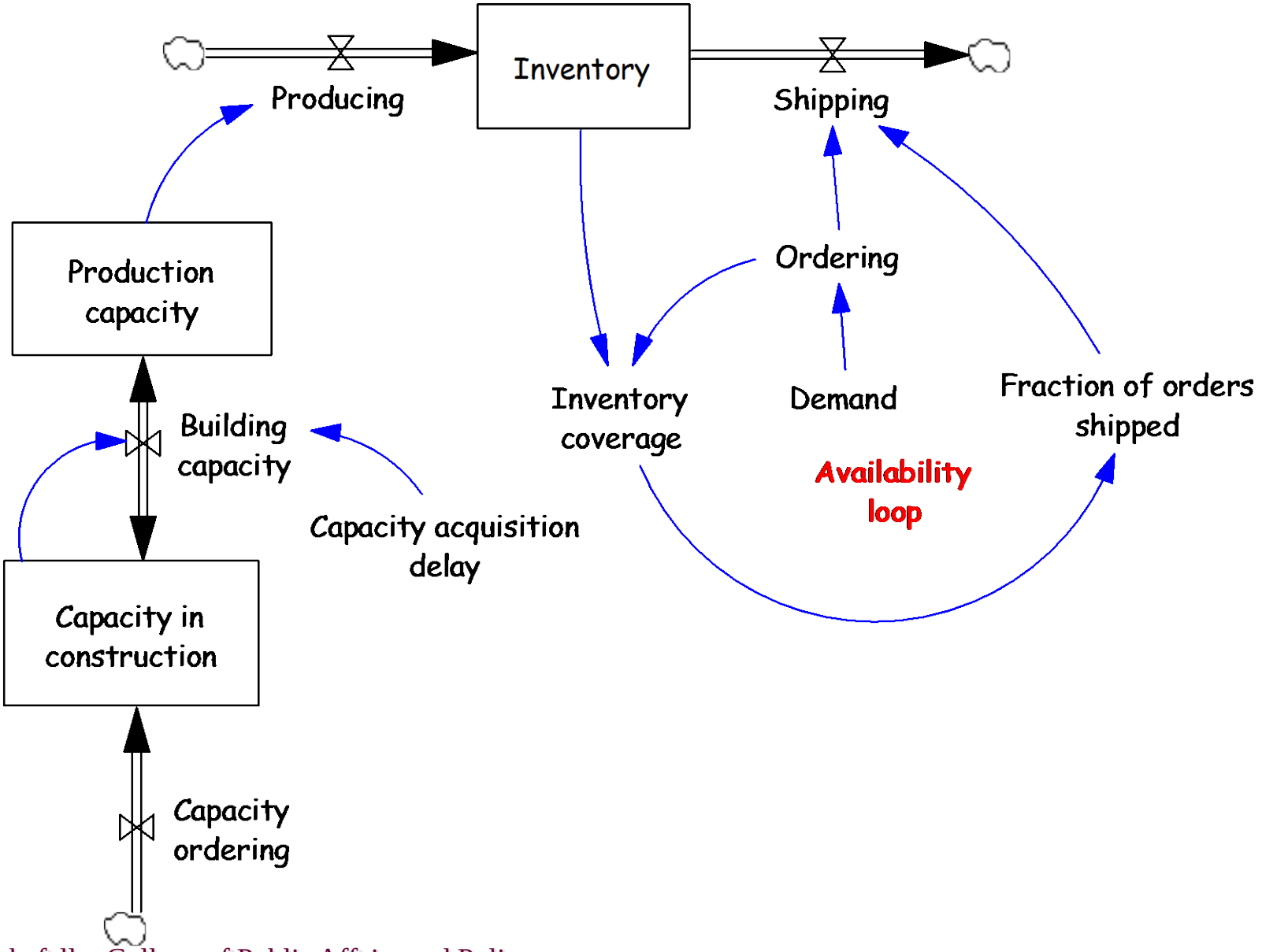
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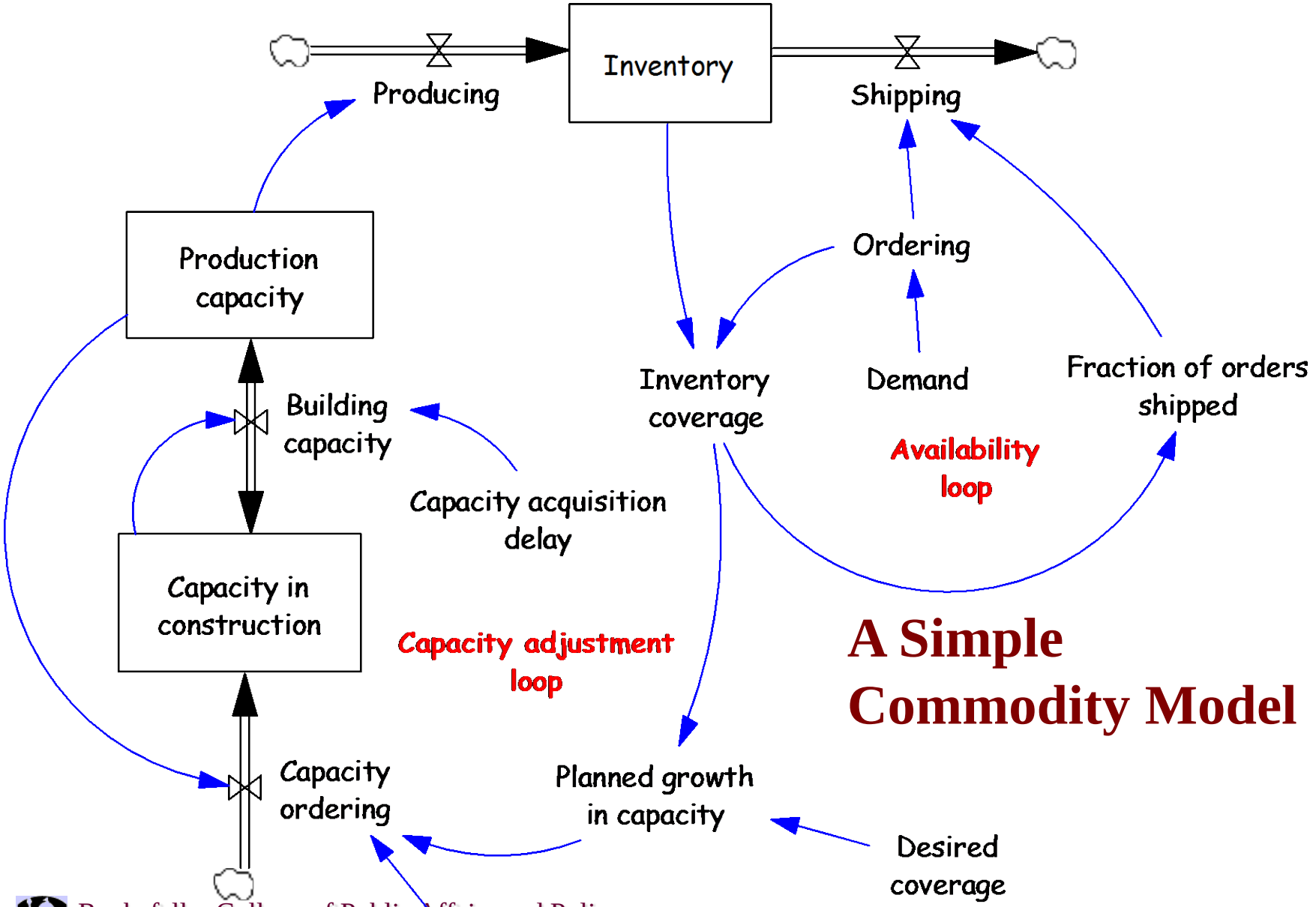
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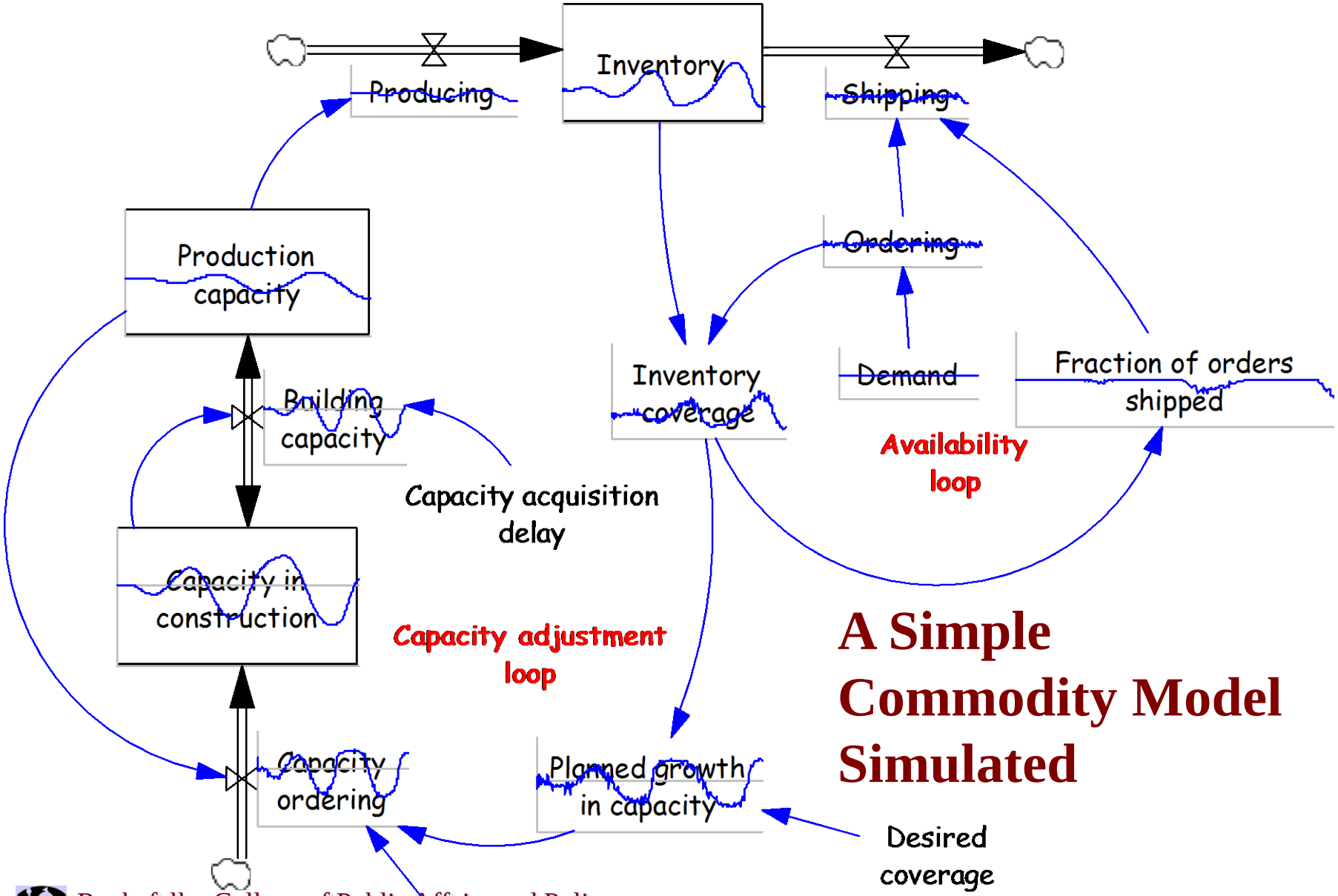
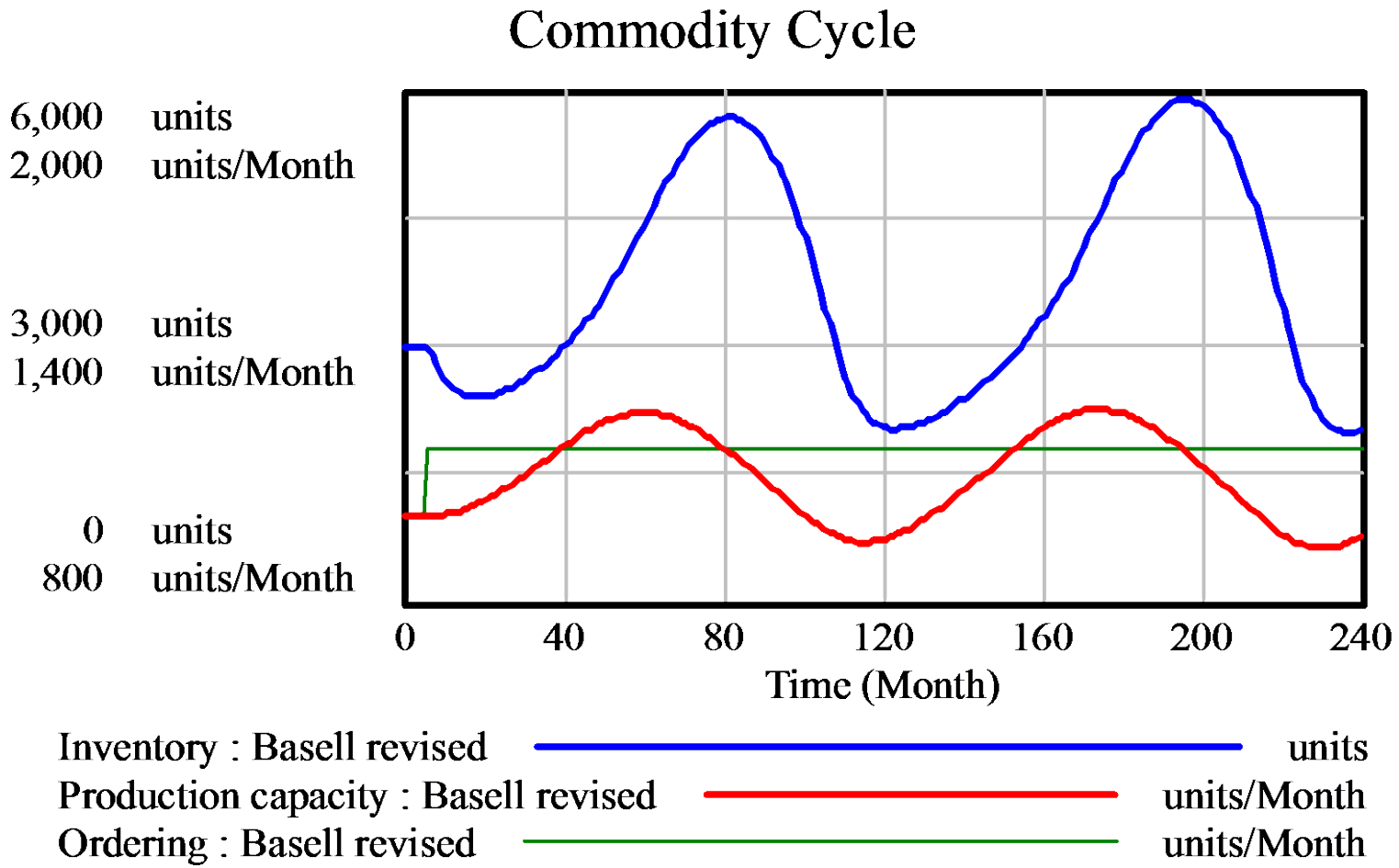
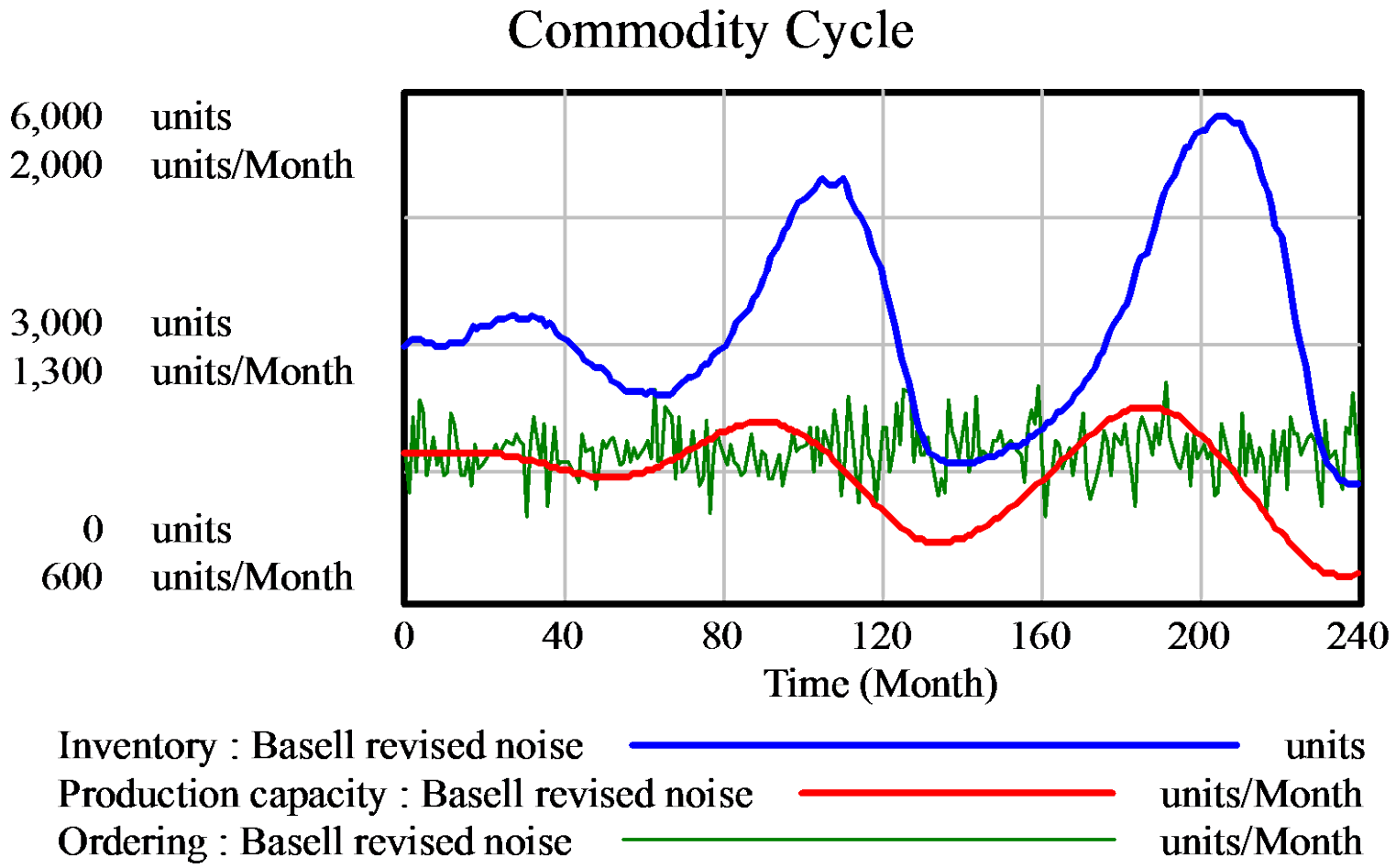


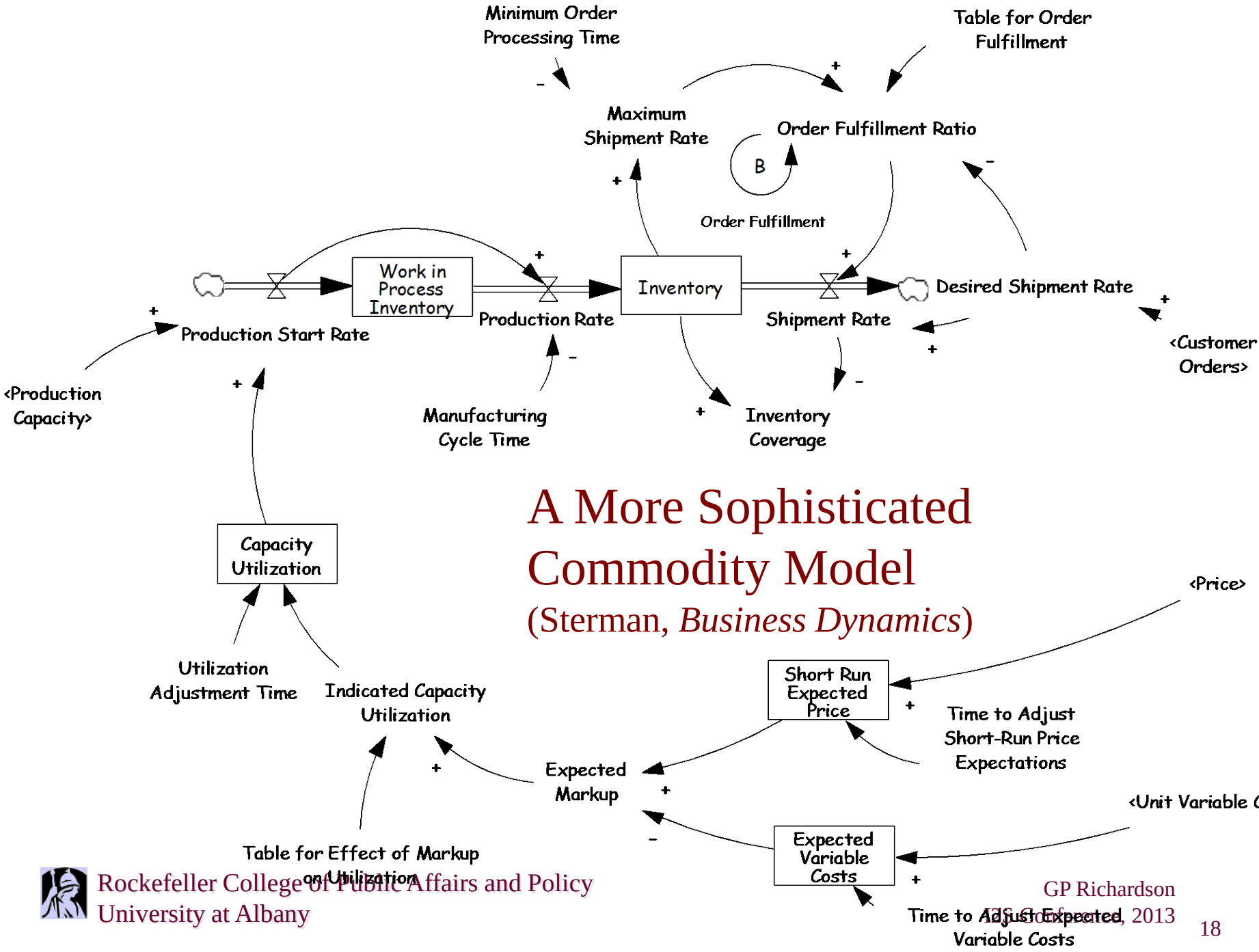
A Simple Commodity Model Simulated

Simple Commodity Model Behavior



Commodity Cycles from Random Disturbances

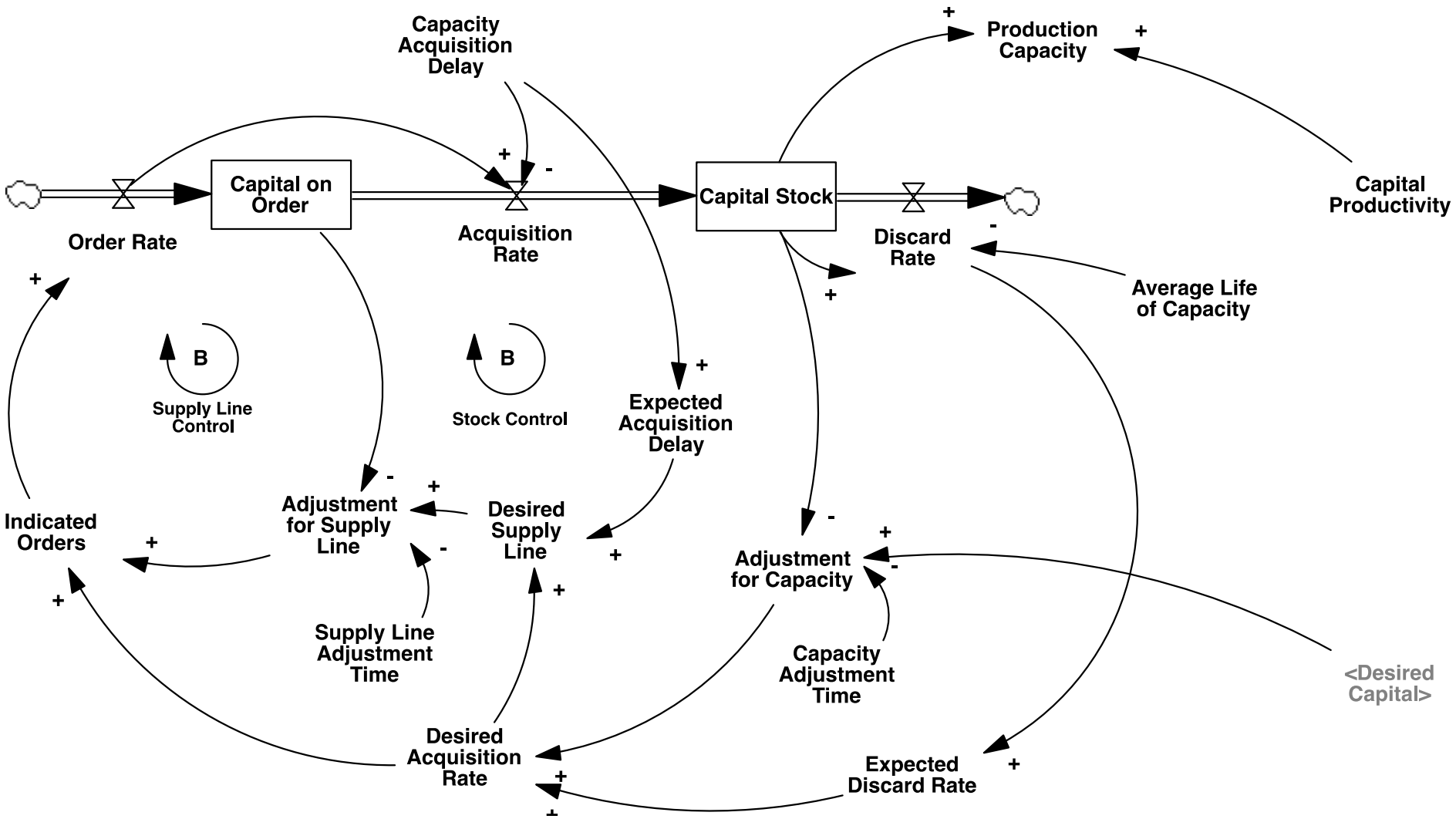




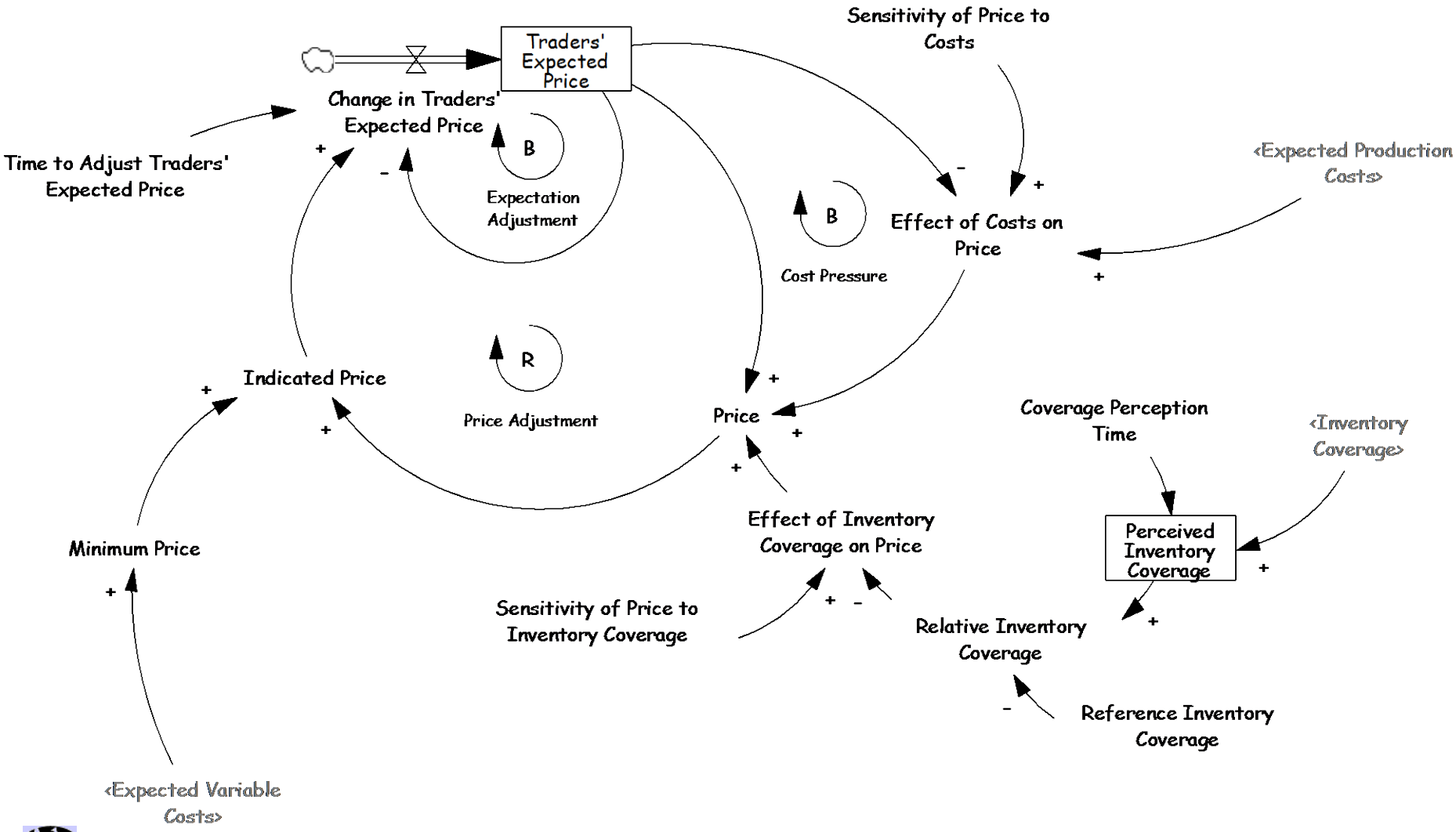
A More Sophisticated Commodity Model

(Sterman, *Business Dynamics*)

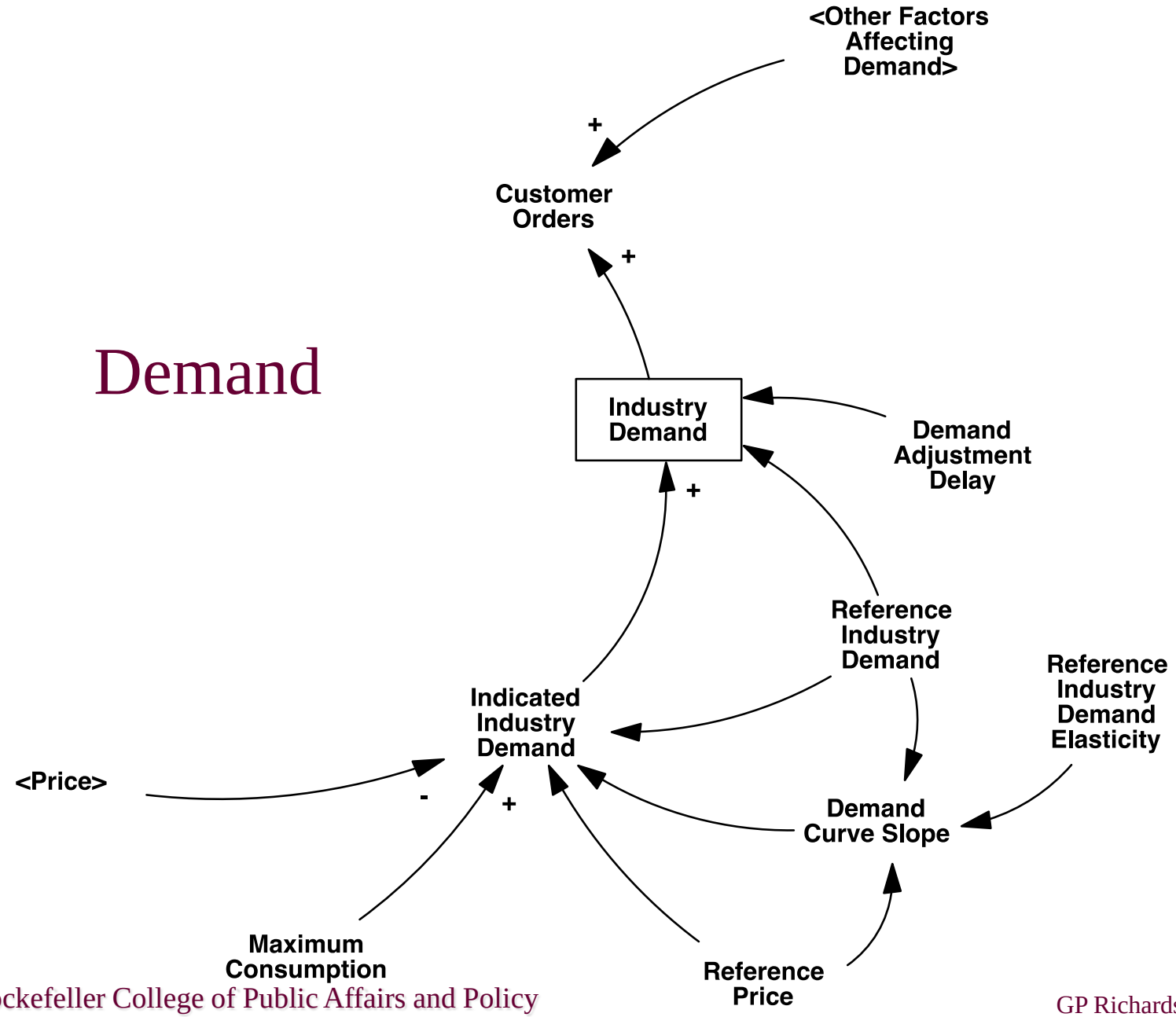
Production Capacity



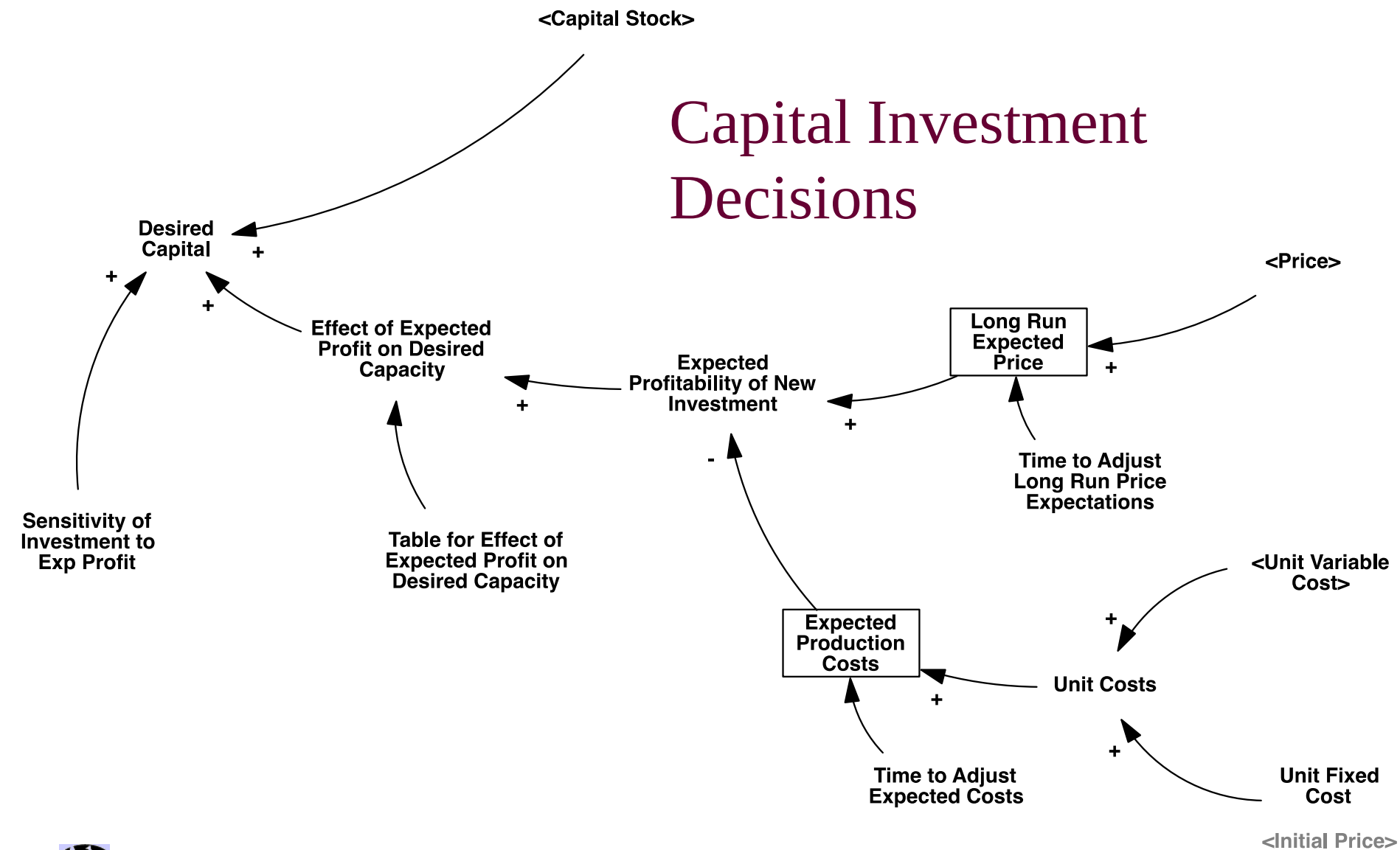
Price Dynamics



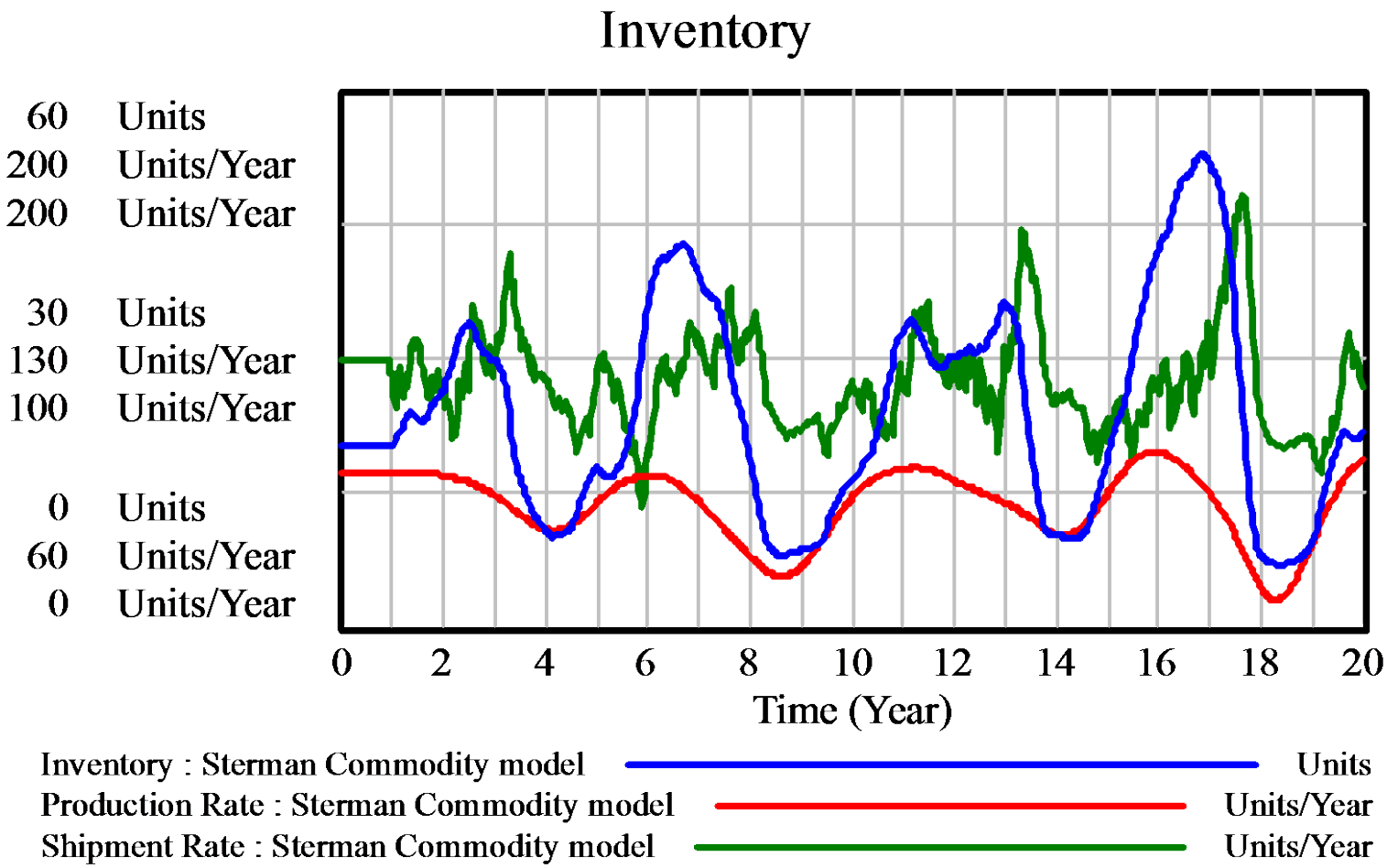
Demand


<Other Factors Affecting Demand>
+
Customer Orders
+
Industry Demand
Demand Adjustment Delay
+
Reference Industry Demand
Reference Industry Demand Elasticity
Indicated Industry Demand
<Price>
-
+
Demand Curve Slope
Maximum Consumption
Reference Price

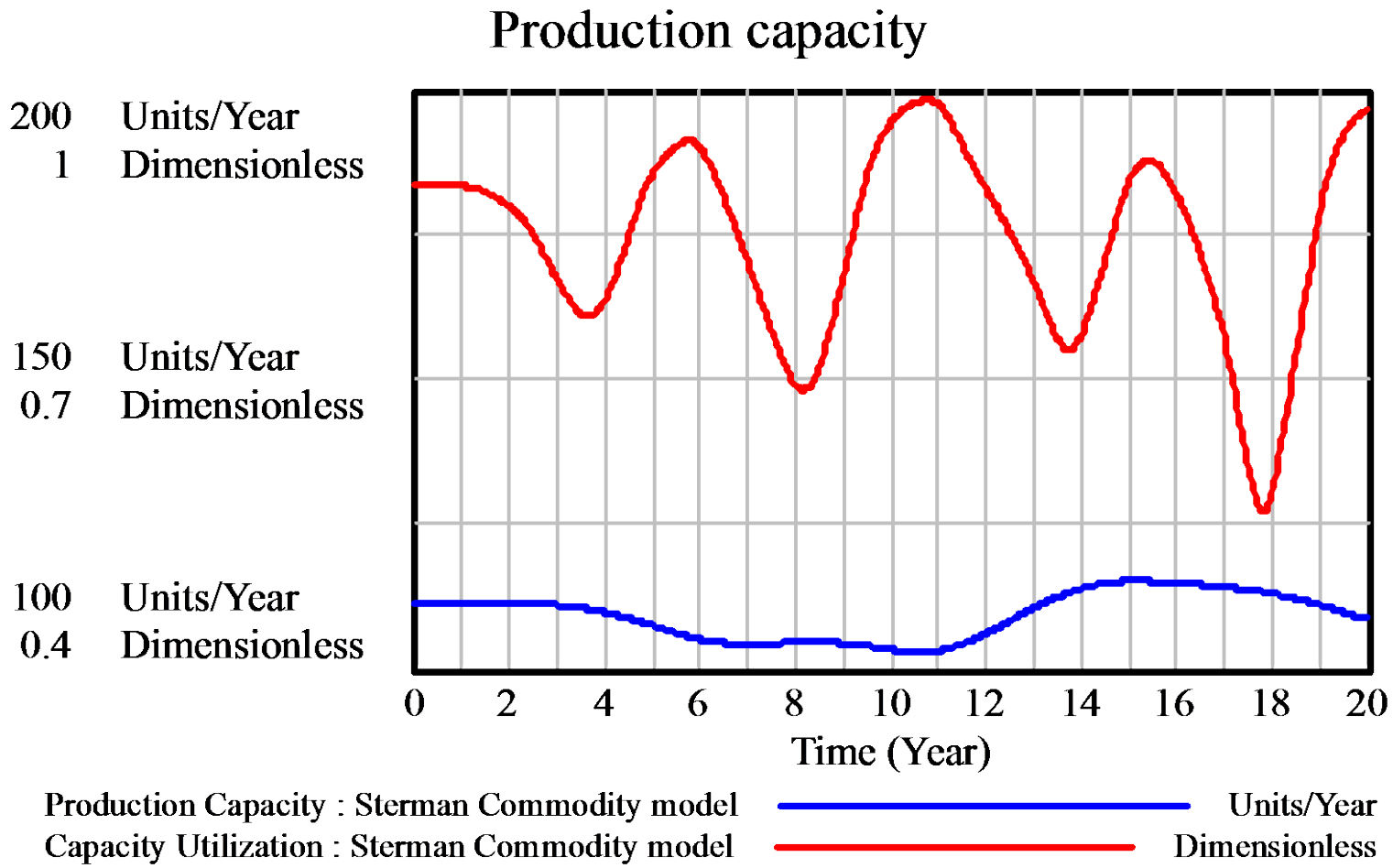
Capital Investment Decisions



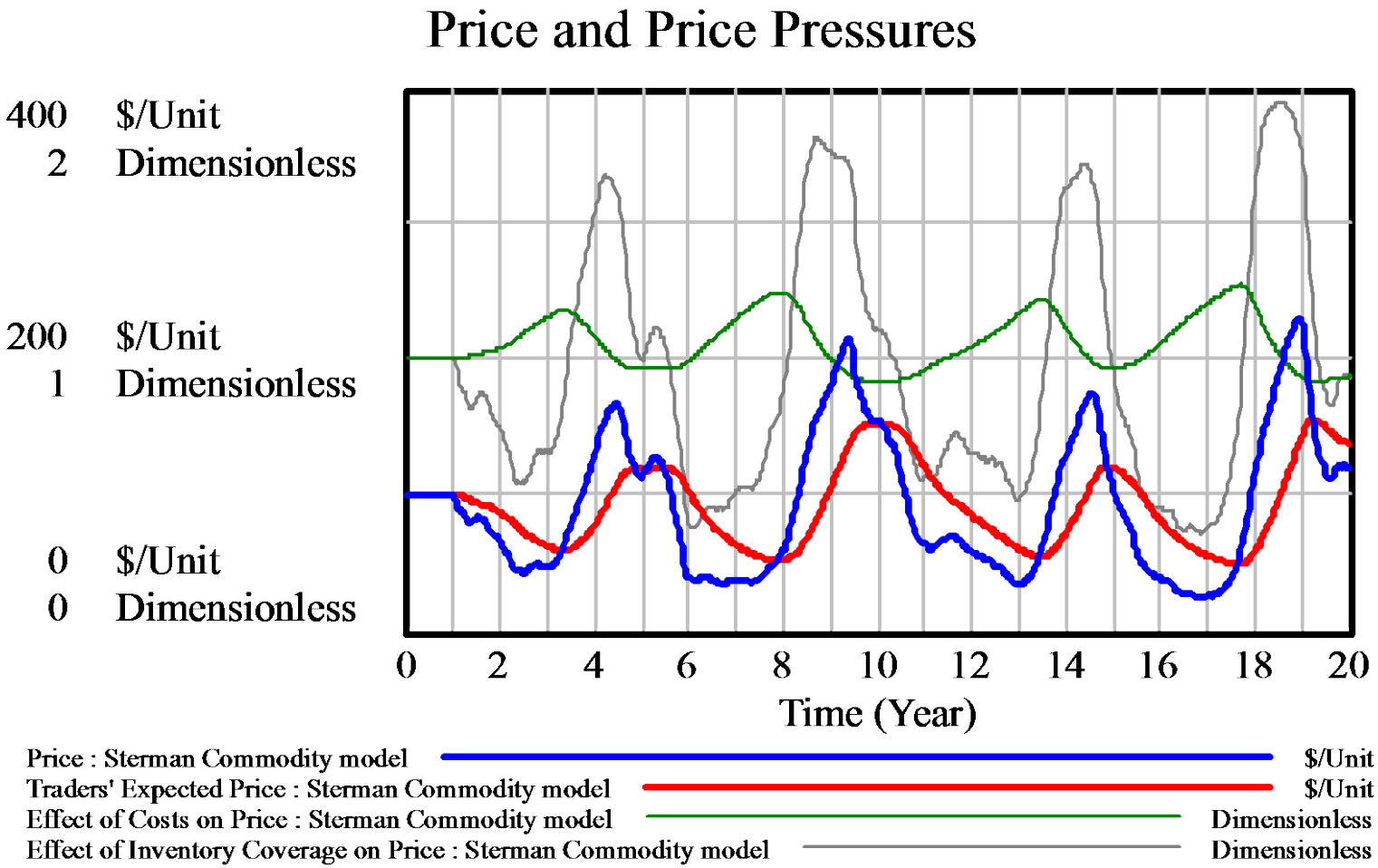
Inventory, Production & Shipments



Production Capacity & Utilization



Prices & Influences on Price



Project Dynamics

Famous Overruns

selected from http://en.wikipedia.org/wiki/Cost_overrun

Australia

- Sydney Olympic Park
- Sydney Opera House

Canada

- Pickering Nuclear Generating Station
- Montreal Olympic Stadium
- Rogers Centre (SkyDome)

Denmark

- Great Belt railway tunnel

Sweden

- Göta Canal
- Hallandsås Tunnel

Japan

- Joetsu Shinkansen high-speed rail line

Malaysia

- Pergau Dam

United Kingdom

- Humber Bridge
- Millennium Dome
- National Programme for IT
- Scottish Parliament Building

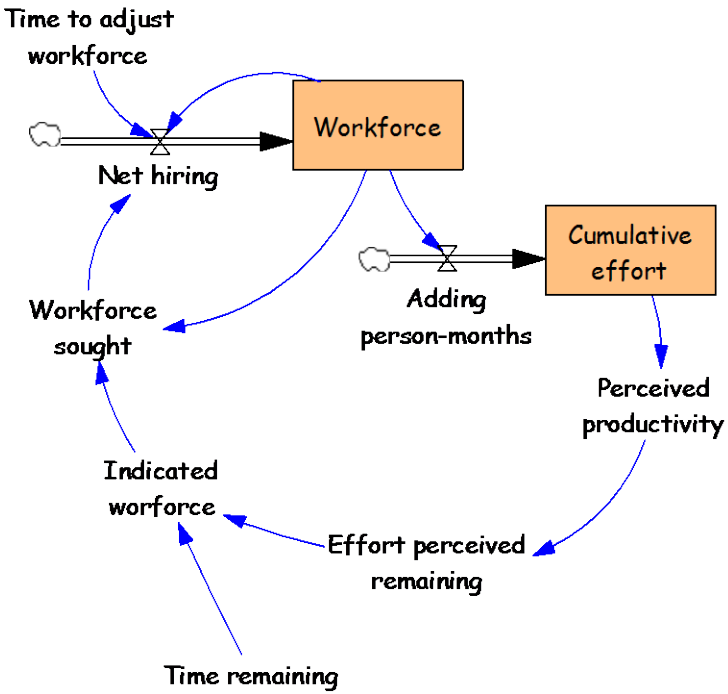
United States

- Big Dig, Boston
- Denver International Airport
- F-22 Raptor
- San Francisco–Oakland Bay Bridge span replacement
- Lockheed Martin F-35 Lightning II
- V-22 Osprey
- Hubble Space Telescope

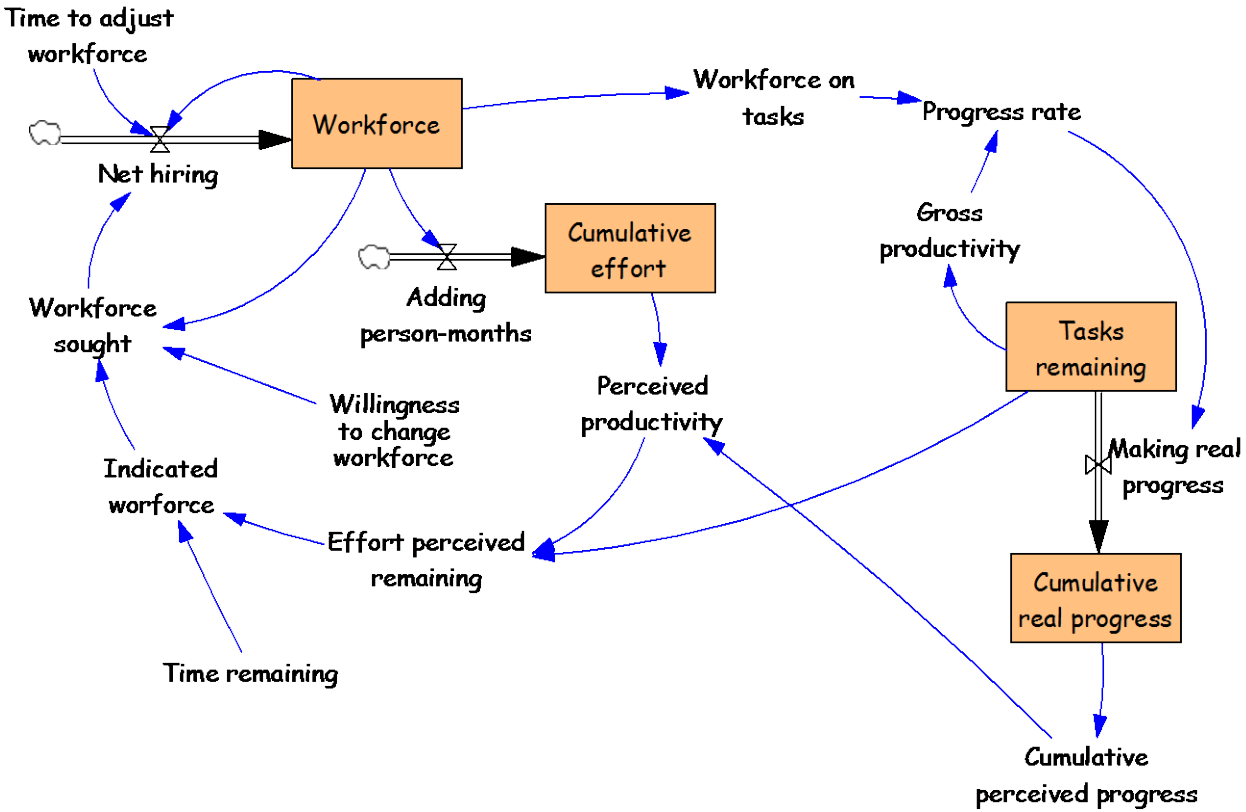
Multinational

- Airbus A380
- Airbus A400M
- Channel Tunnel
- Concorde
- Eurofighter

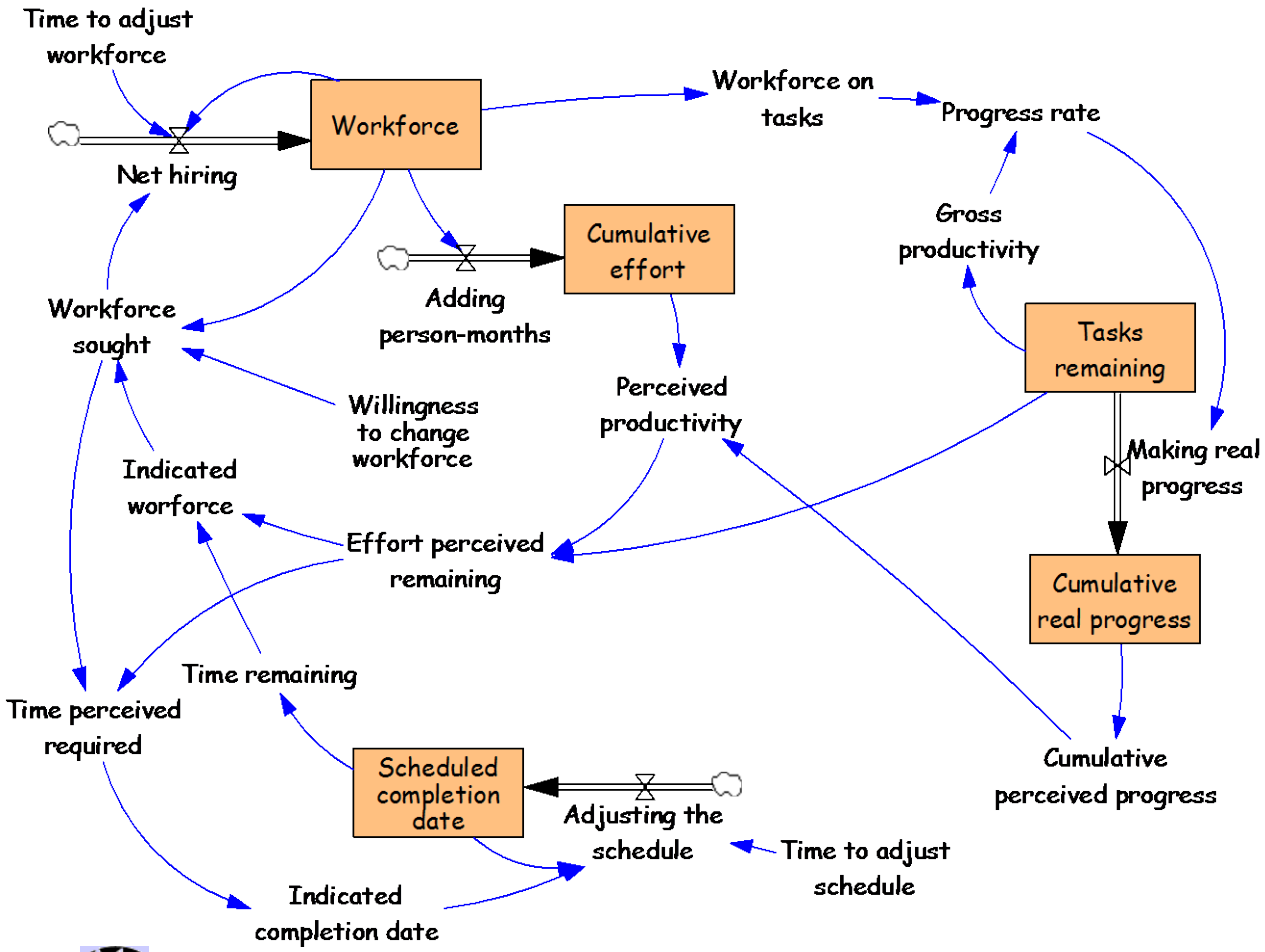
Modeling Project Dynamics



Modeling Project Dynamics

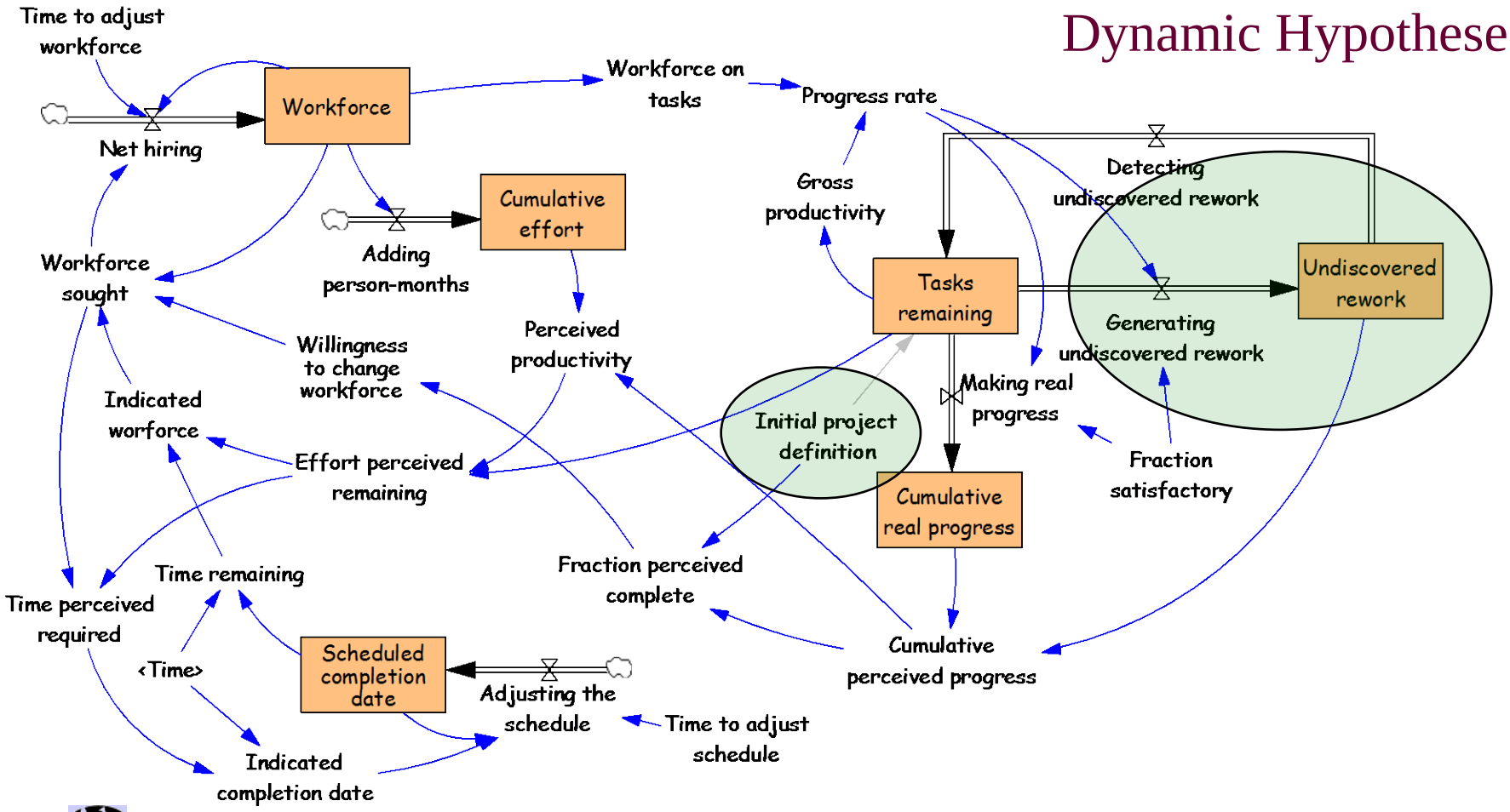


Modeling Project Dynamics

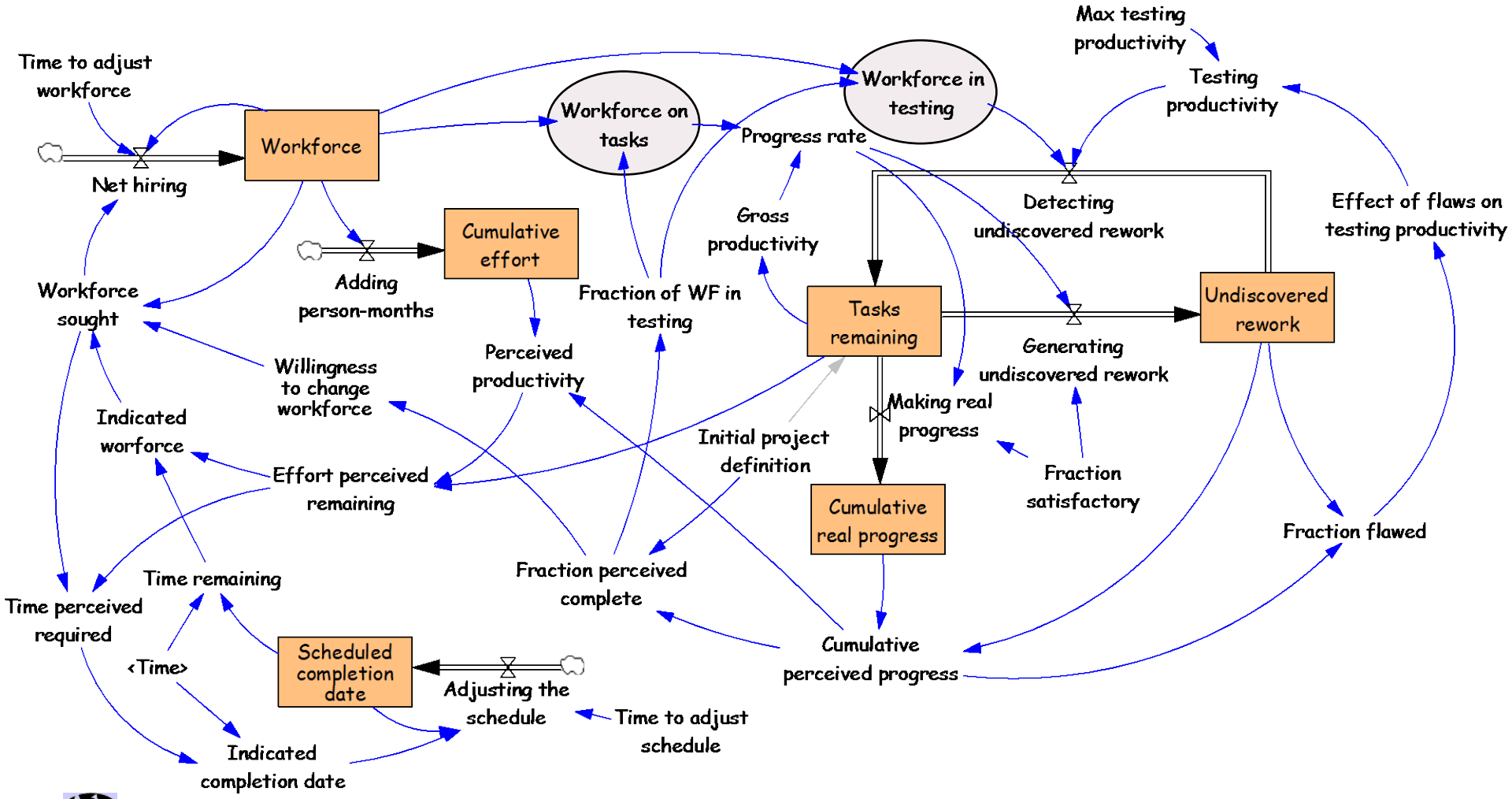


Modeling Project Dynamics

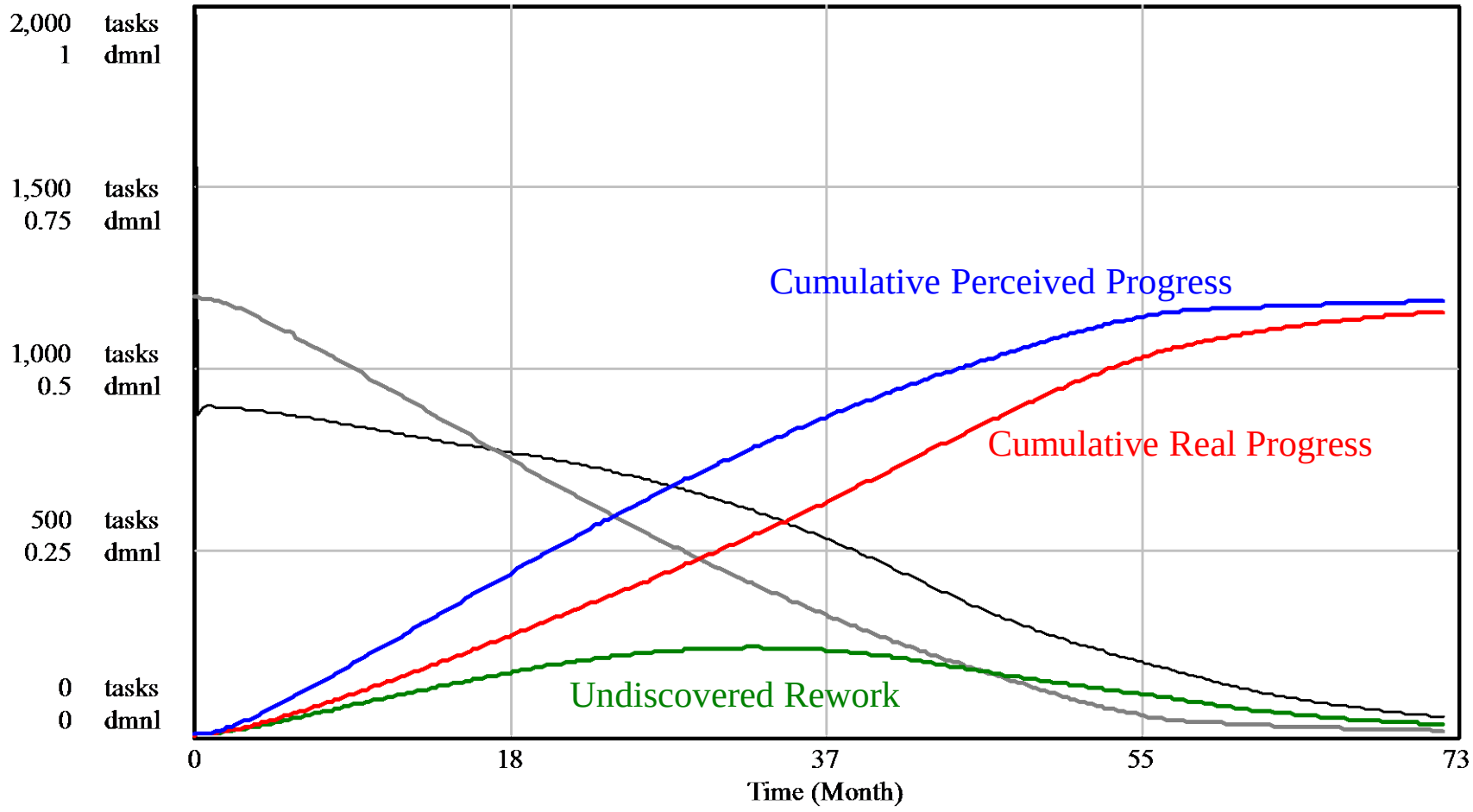
Dynamic Hypotheses



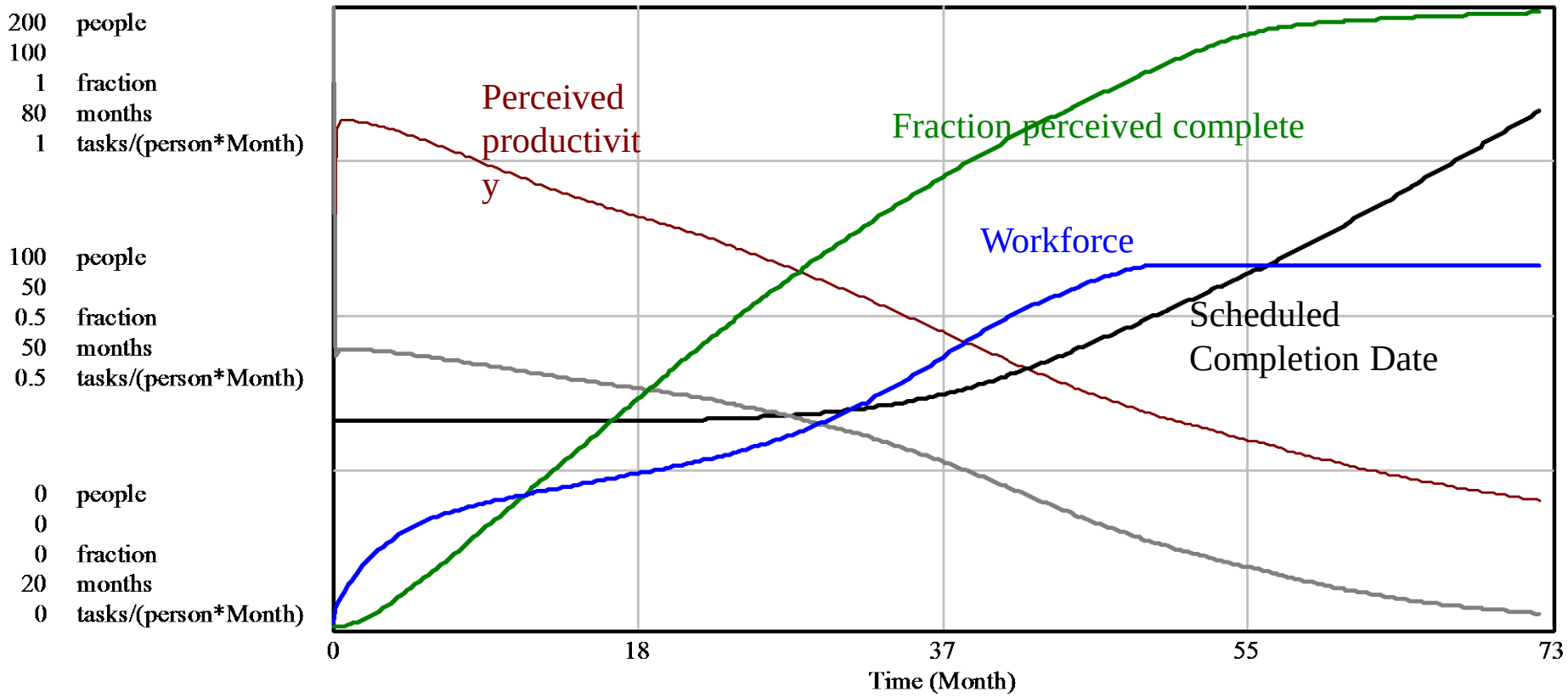
Modeling Project Dynamics



Tasks


2,000 tasks
1 dmnl
1,500 tasks
0.75 dmnl
1,000 tasks
0.5 dmnl
500 tasks
0.25 dmnl
0 tasks
0 dmnl
Cumulative Perceived Progress
Cumulative Real Progress
Undiscovered Rework
0
18
37
55
73
Time (Month)
Cumulative perceived progress : Project dynamics tasks
Cumulative real progress : Project dynamics tasks
Undiscovered rework : Project dynamics tasks
Tasks remaining : Project dynamics tasks
Fraction flawed : Project dynamics dmnl

Project Dynamics



Impactful Project Modeling

- Litton Industry ship building litigation
  - Cooper, K. G. (1980). Naval Ship Production: A Claim Settled and Framework Built. *Interfaces* 10(6)
- Channel Tunnel litigation
  - Eden, Ackermann & Howick, University of Strathclyde
- Fluor Corporation project management
  - Kenneth Cooper and Gregory Lee, System Dynamics Society Application Award 2009, *System Dynamics Review* 24,4 (winter 2009): 339-341.
- And many others by Pugh-Roberts, PA Consulting, Greenwood Strategic Advisors, and others

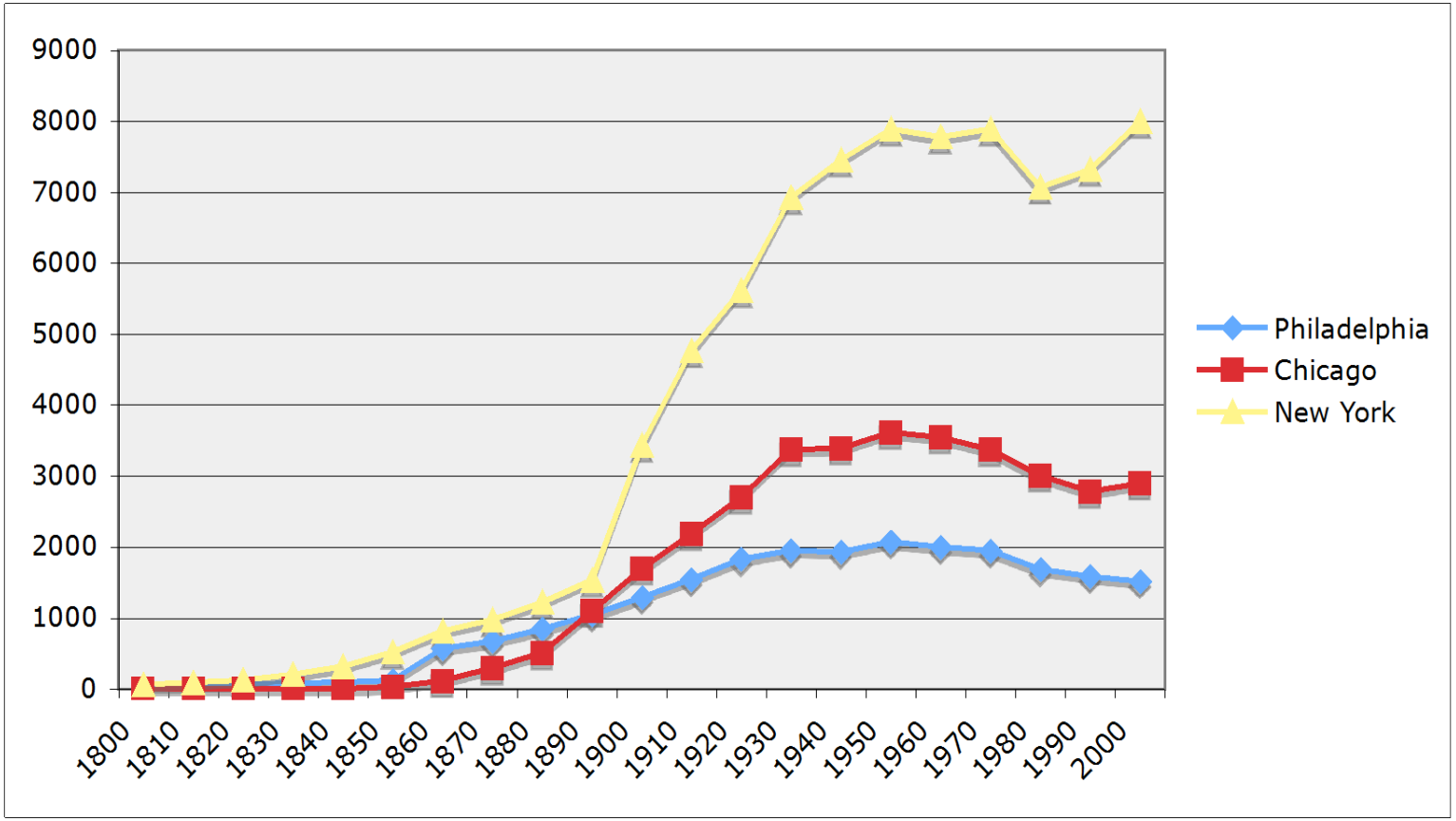
Urban Dynamics

Urban Dynamics

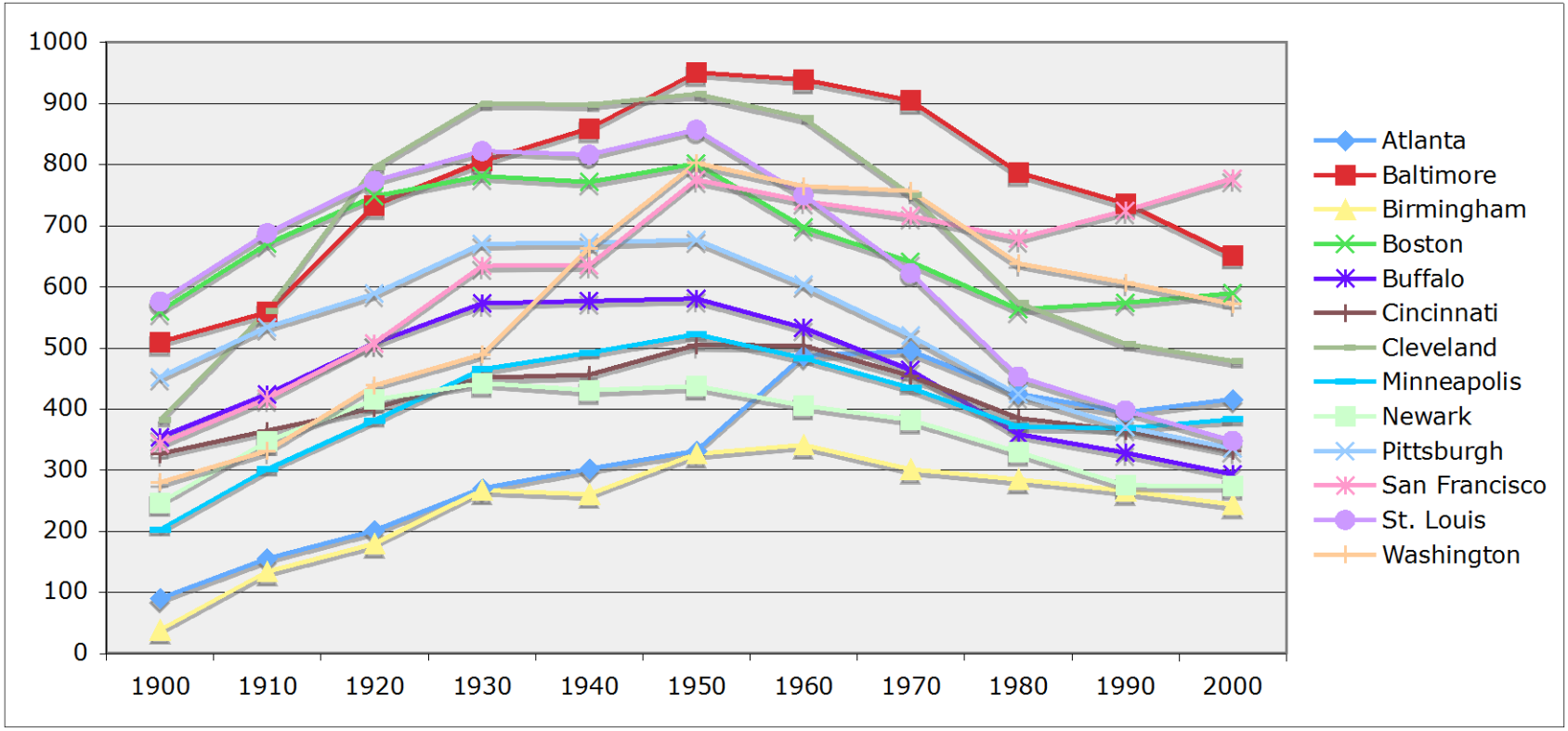
- J.W. Forrester, *Urban Dynamics* (1969). MIT Press. Reprinted by Pegasus Communications.
- L. Alfeld and A. Graham, *Introduction to Urban Dynamics* (1976). MIT Press. Reprinted by Pegasus Communications.

- **The Problem:** Understanding urban growth, stagnation, and decline

New York, Chicago & Philadelphia, 1800-2000



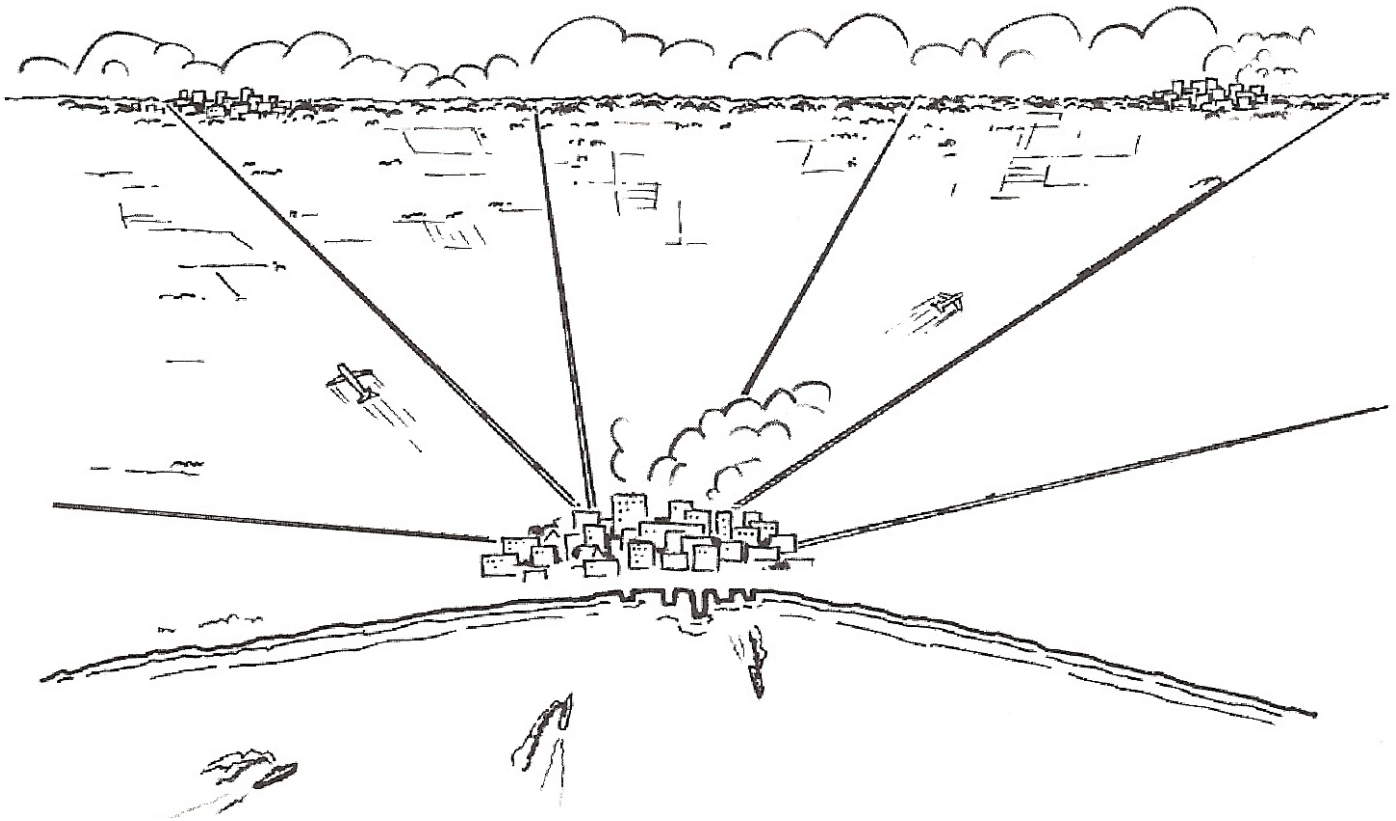
Populations of Selected U.S. Cities, 1900-2000



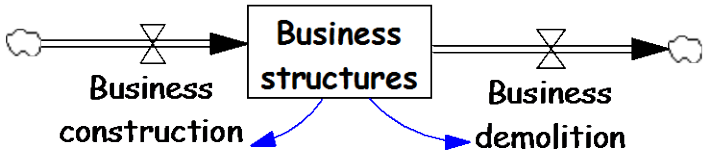
Urban Decay Camden, NJ, USA

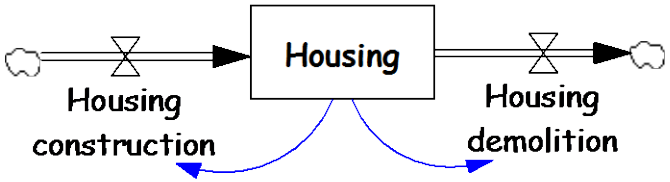
http://en.wikipedia.org/wiki/File:Camden_NJ_poverty.jpg

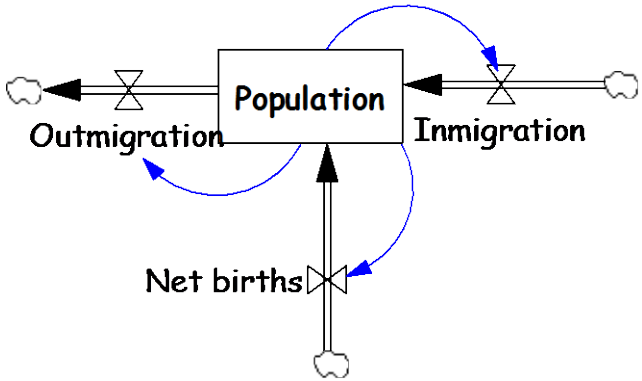
Forrester's City: Endogenous Dynamics



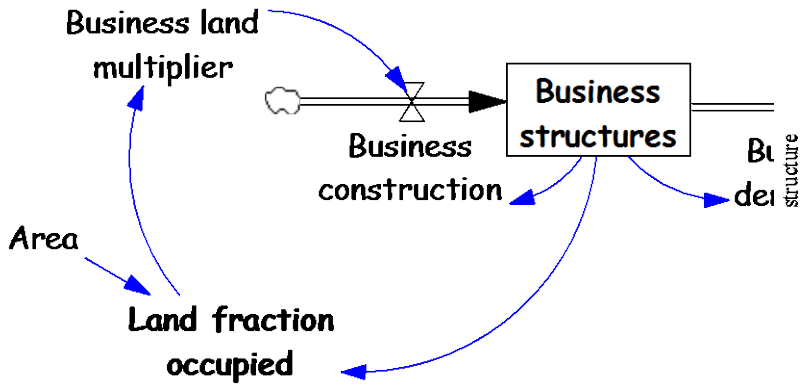
Simple Urban Model: URBAN1

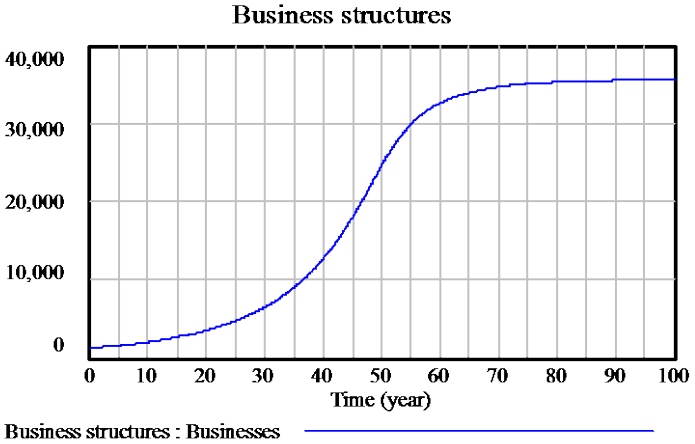


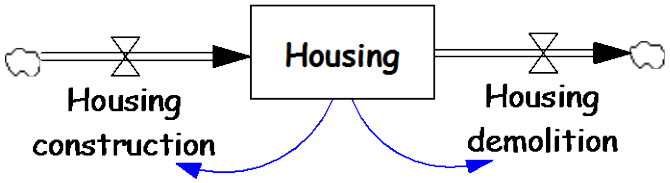


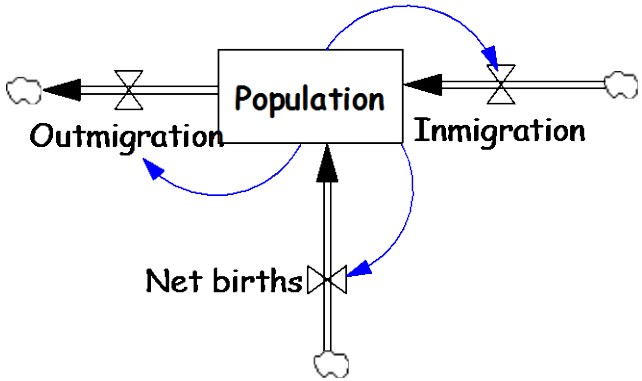


Simple Urban Model: URBAN1









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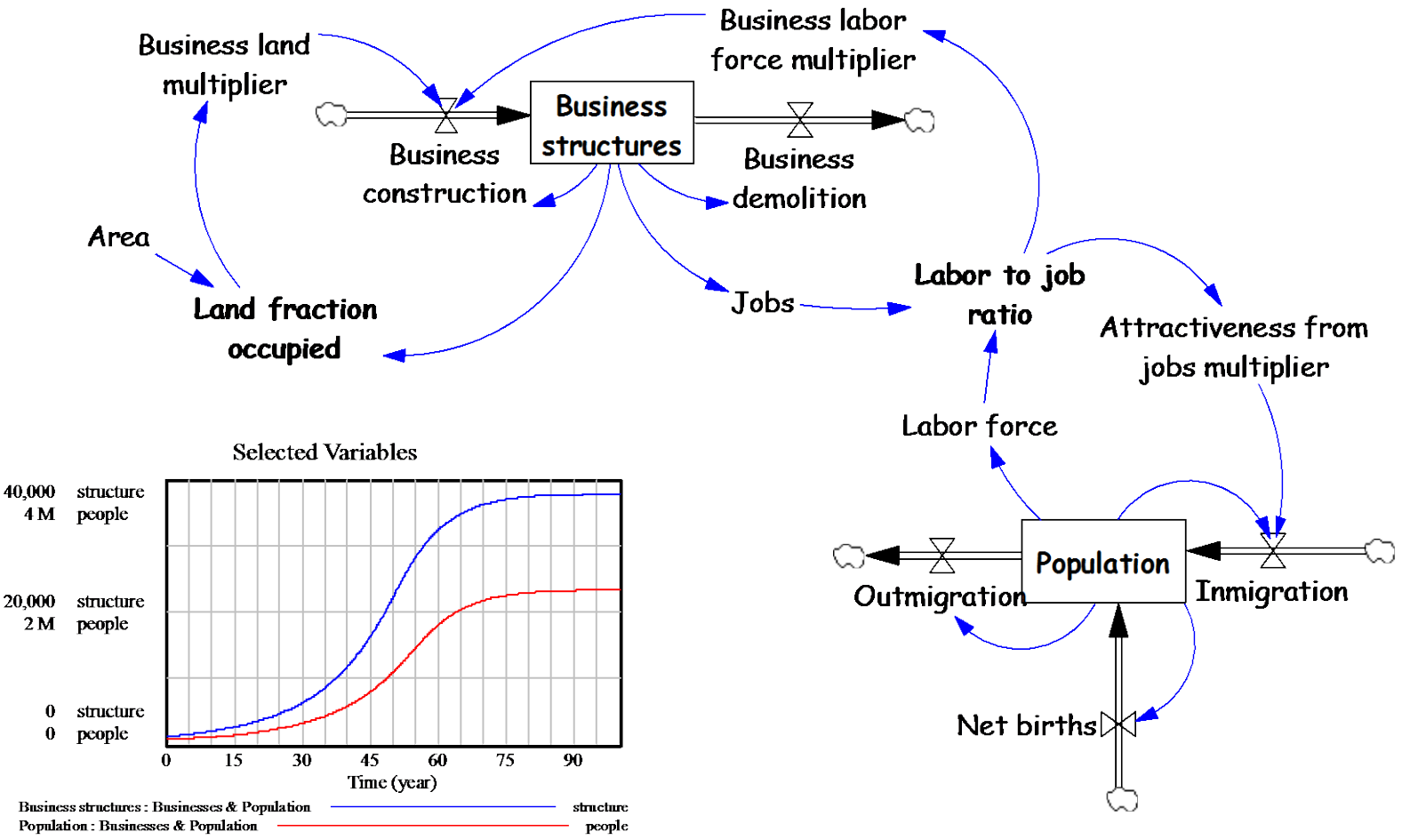
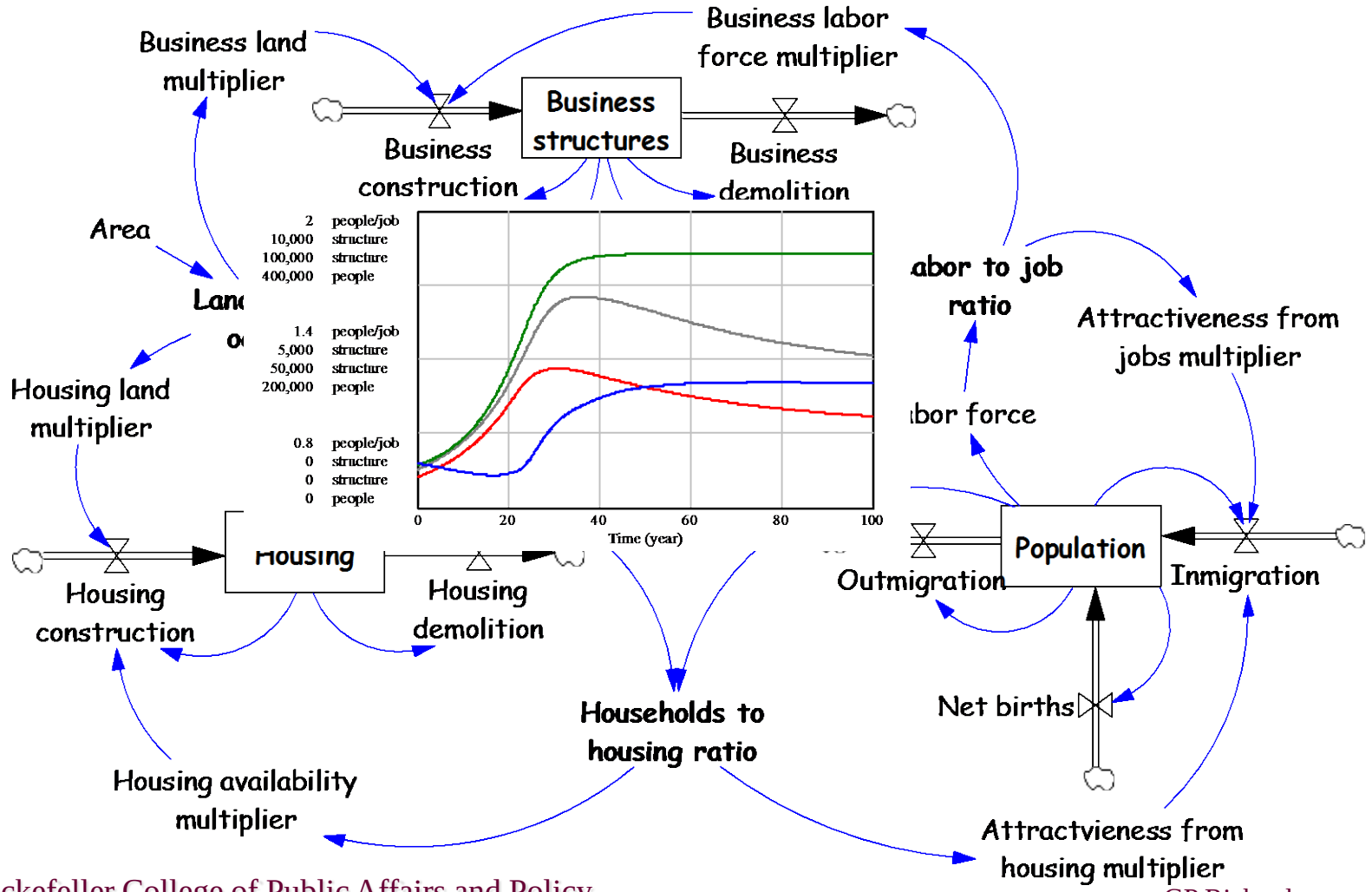
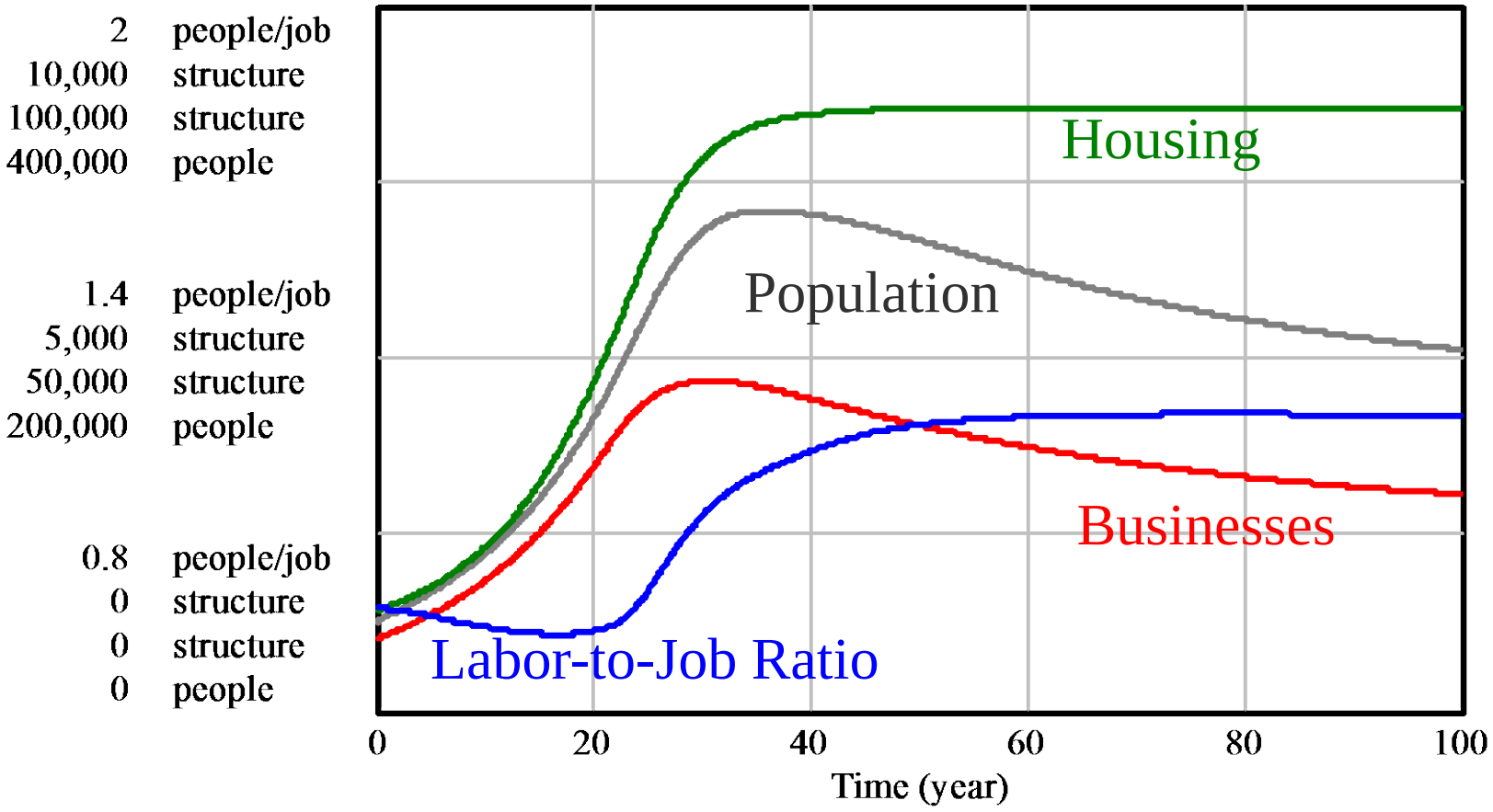


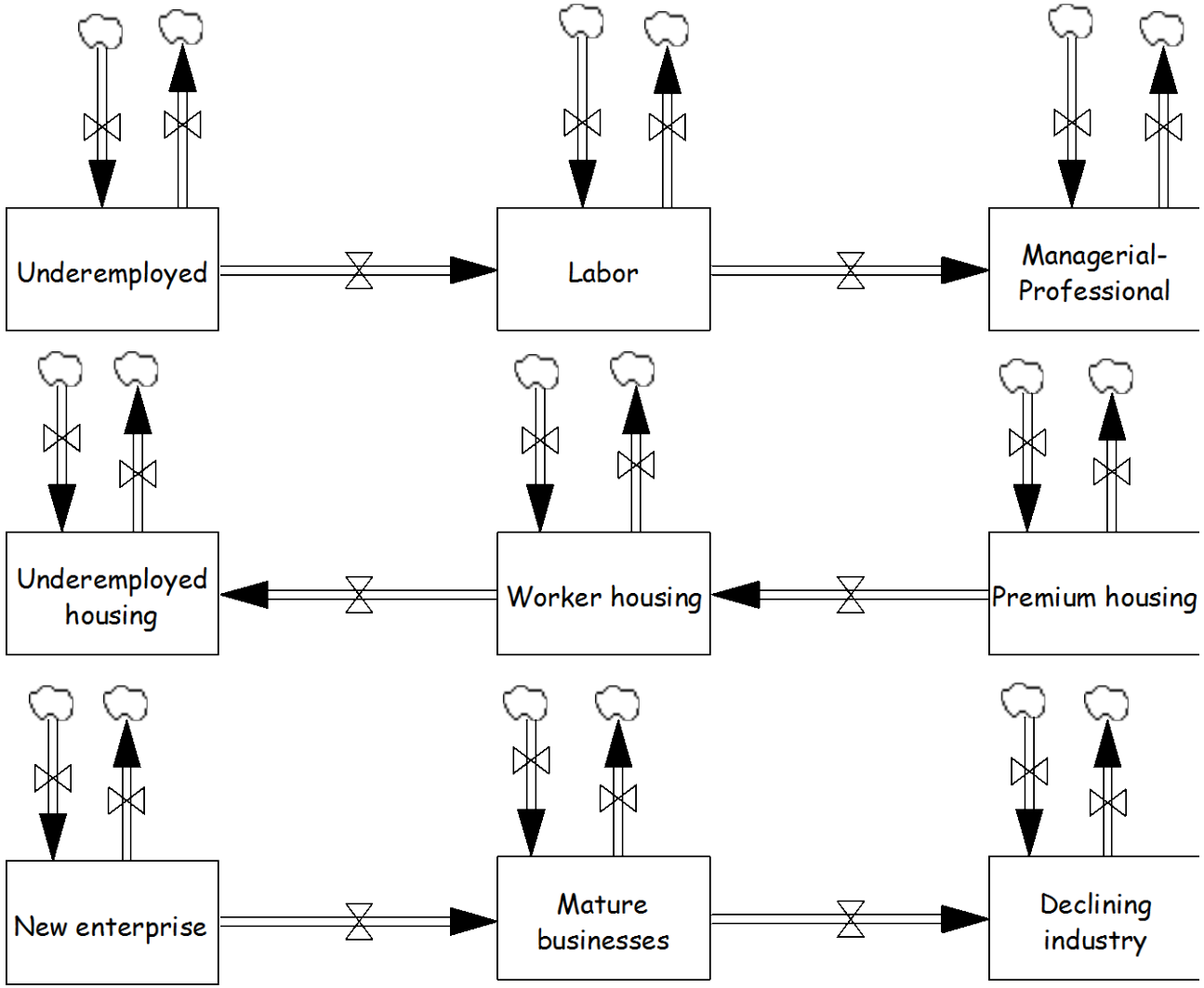
Simple Urban Model: URBAN1



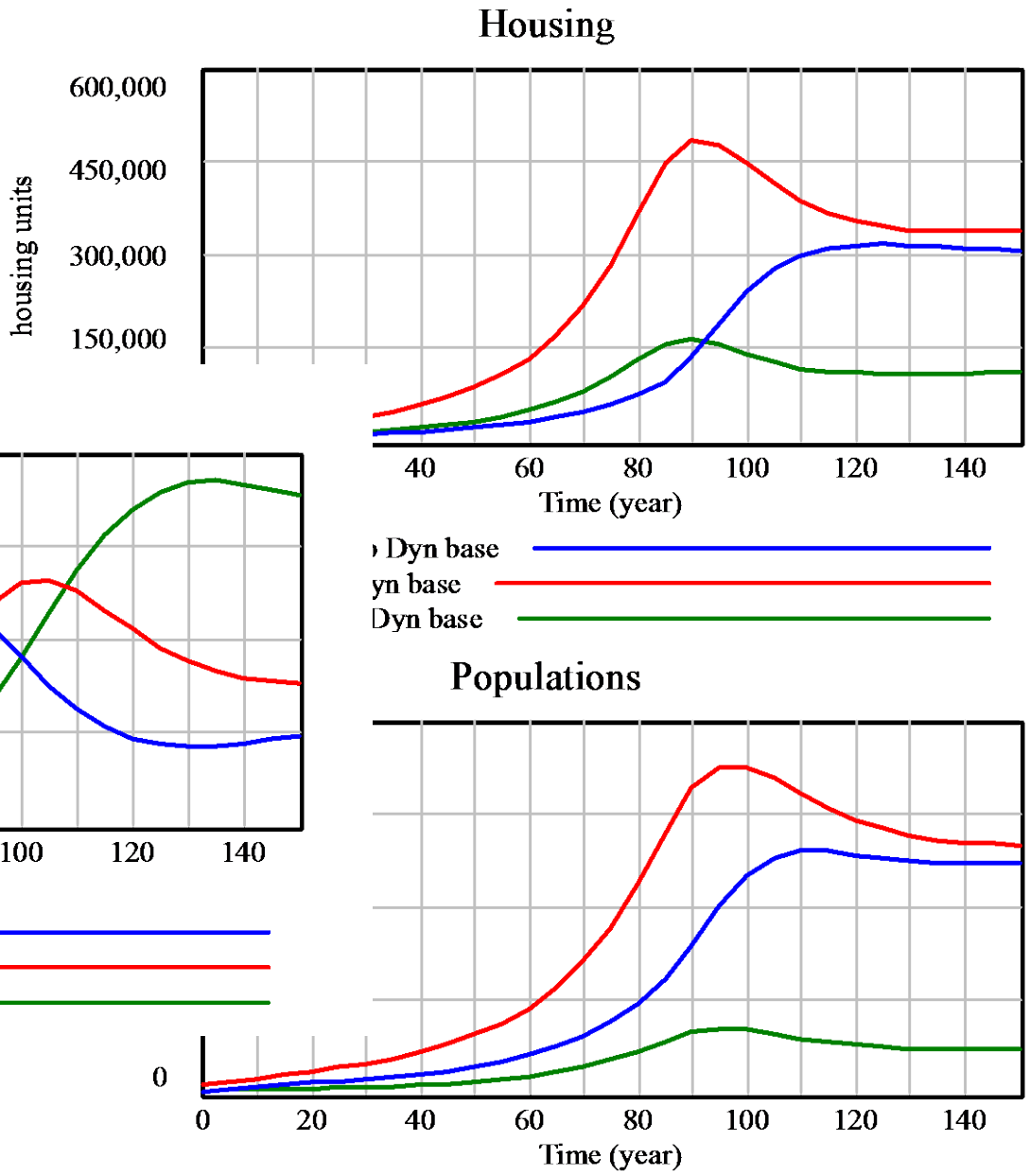
Dynamics of Urban1: Growth, Stagnation & Decline



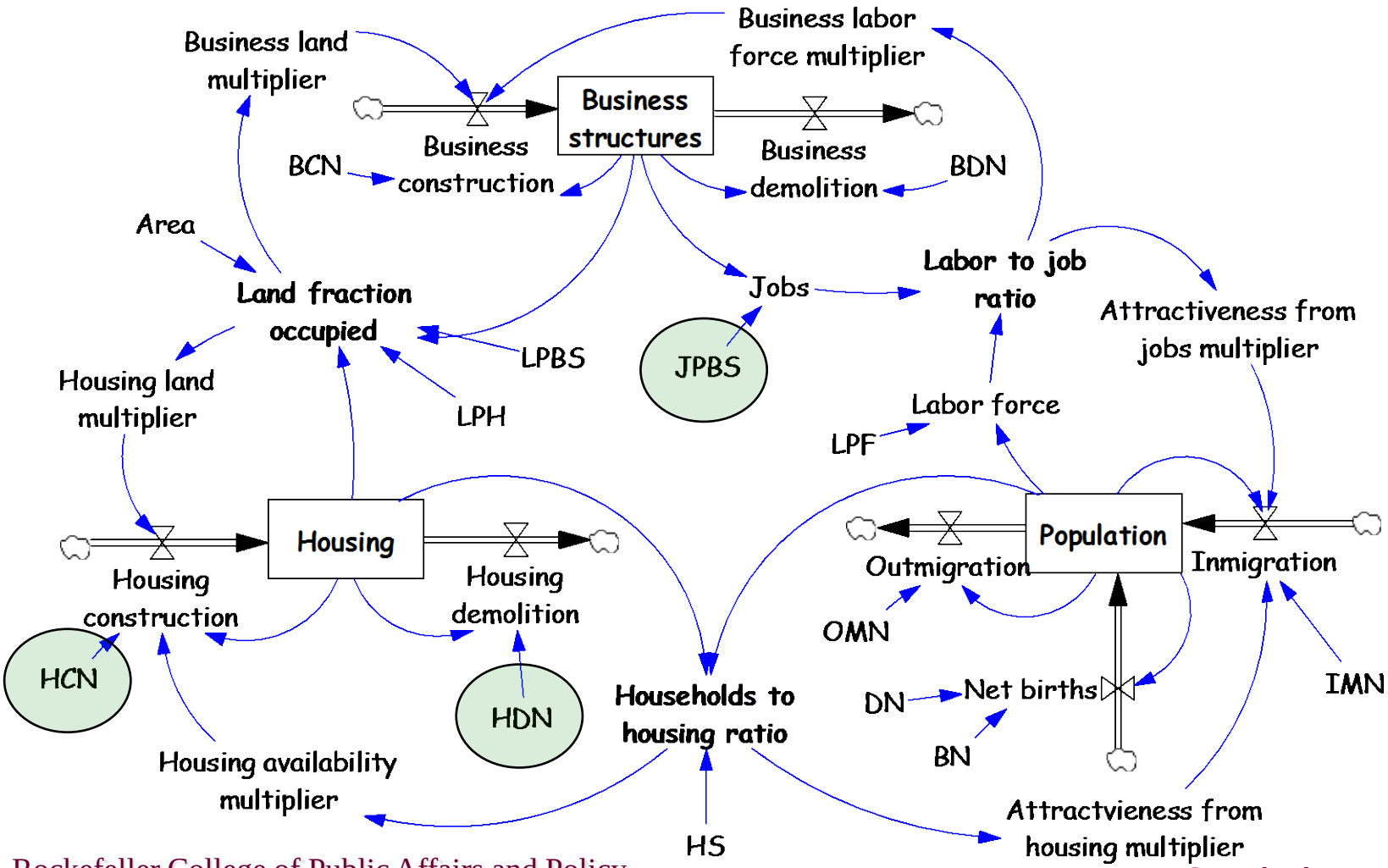
Urban Dynamics Core Structure



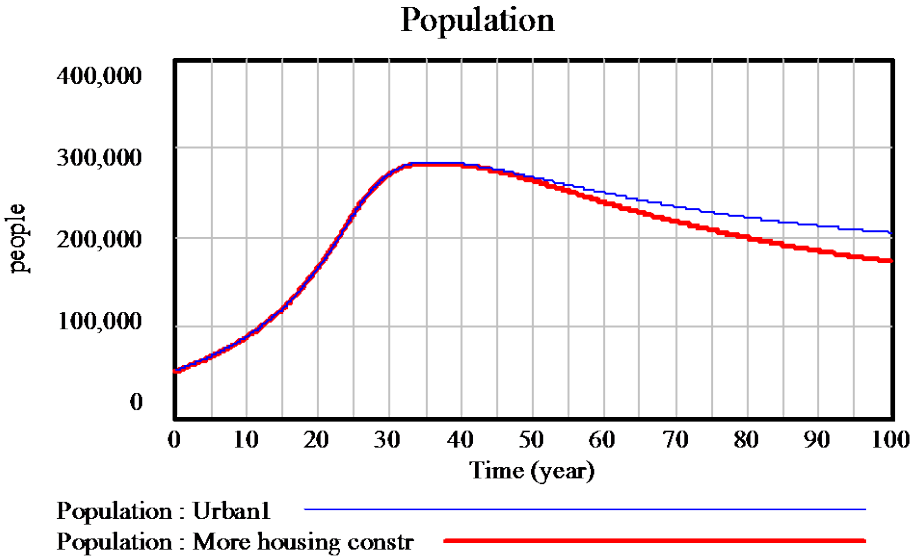
Urban Dynamics Key Stocks

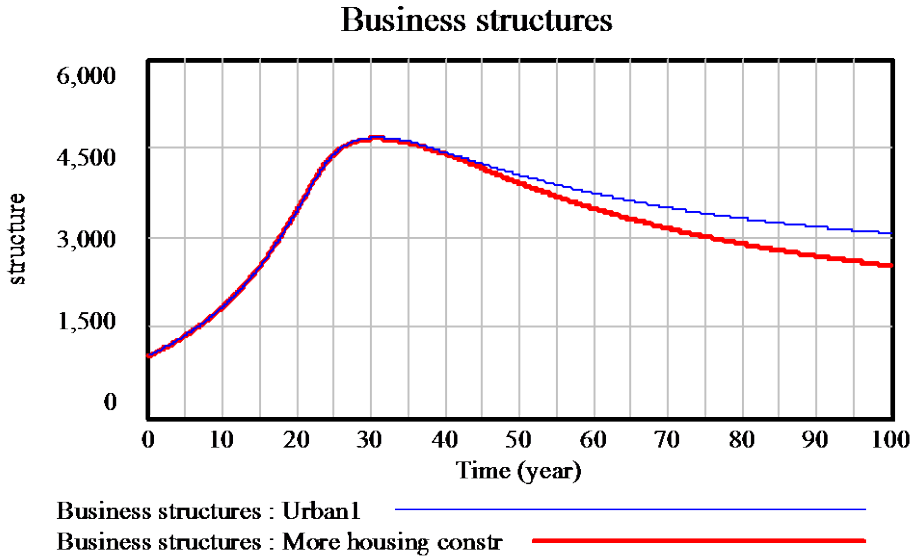


Selected Policy Parameters in URBAN1

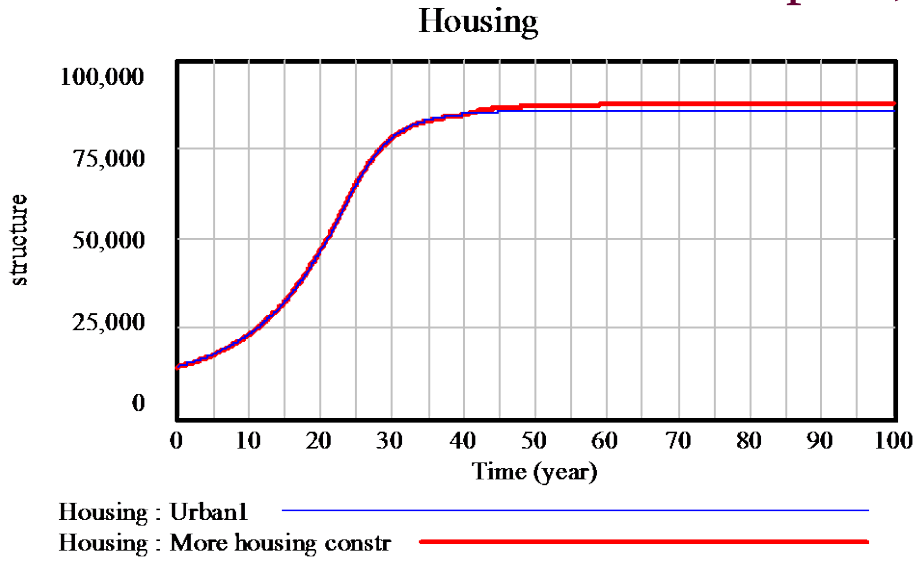


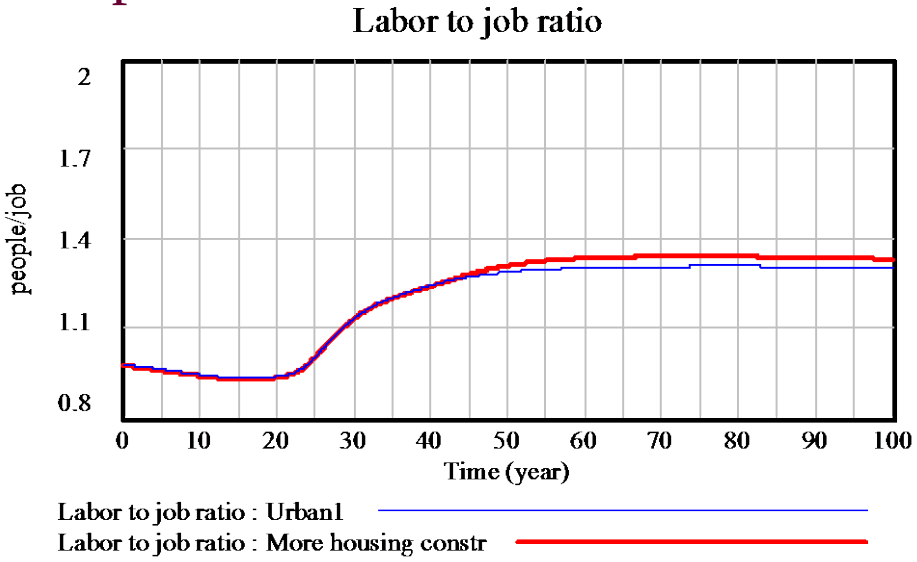
Building low cost housing ($t \geq 40$)



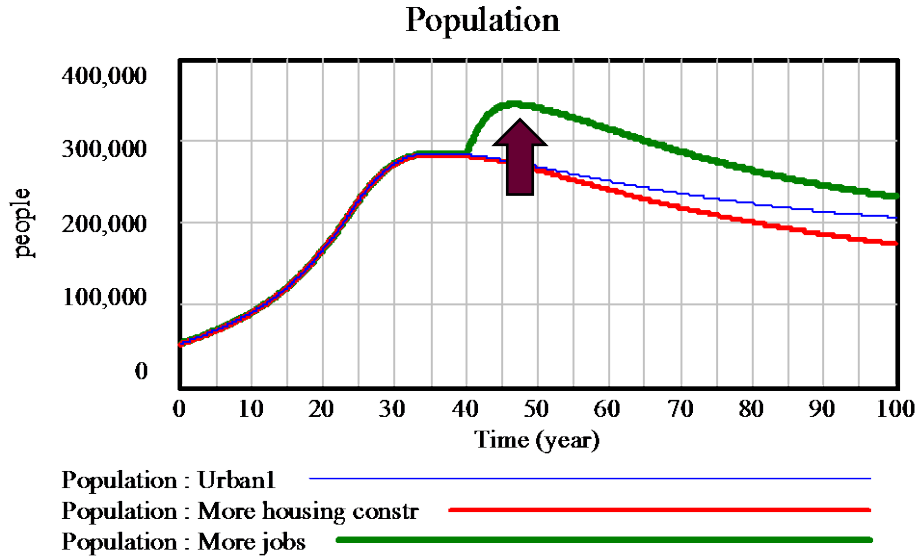


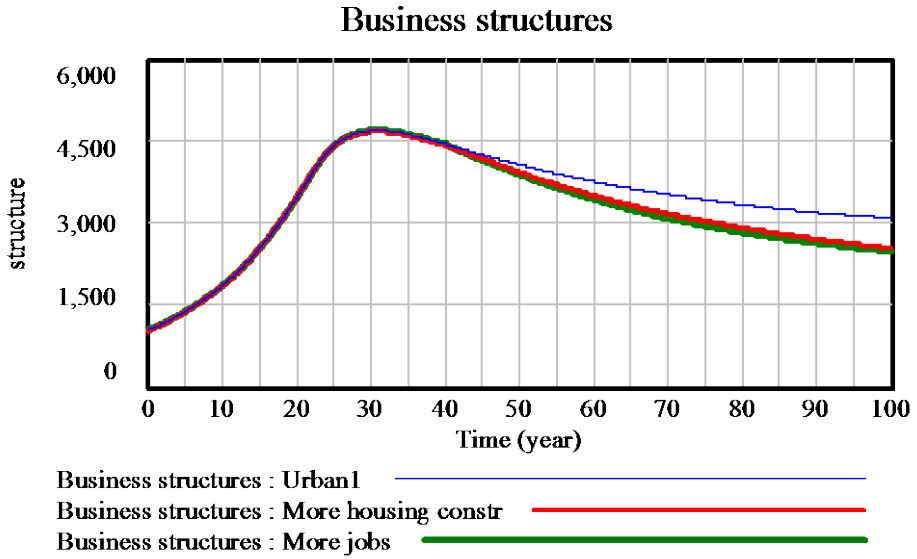
Little impact, no improvement



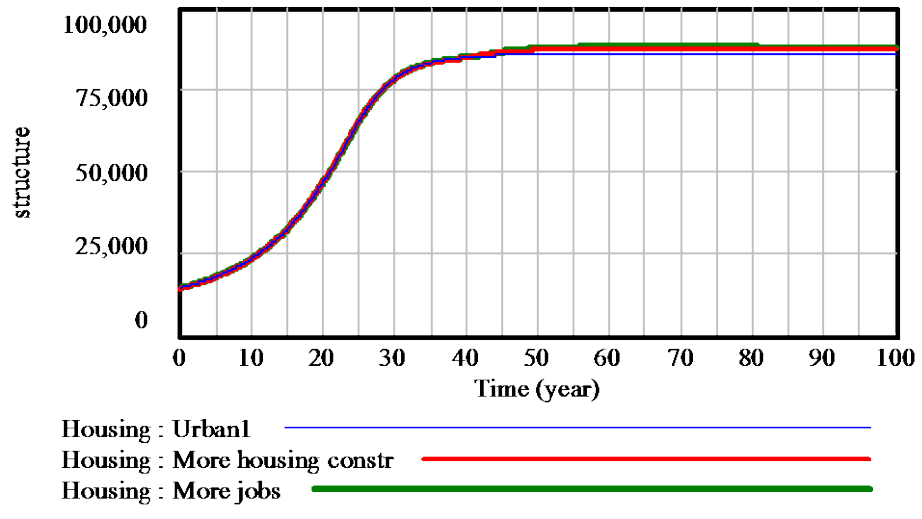


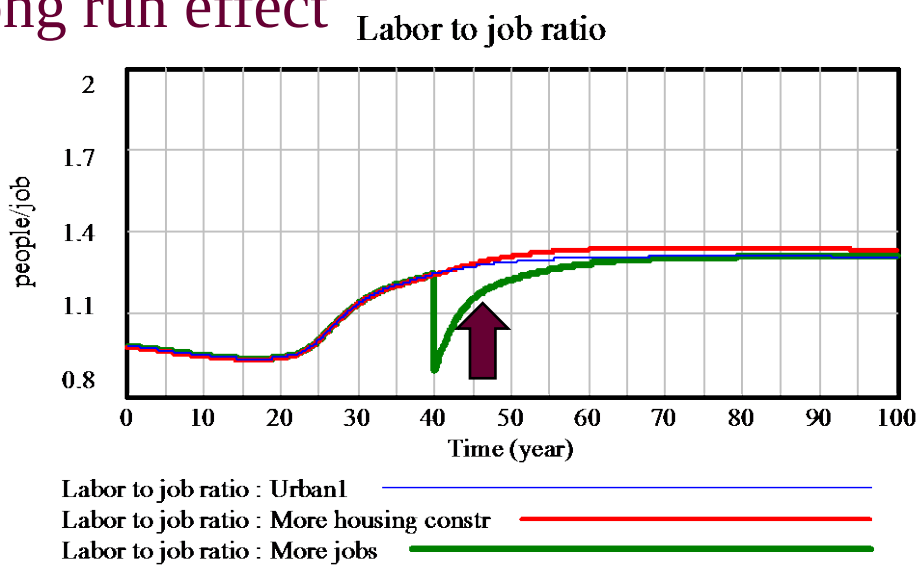
Wildly successful jobs program ($t \geq 40$)



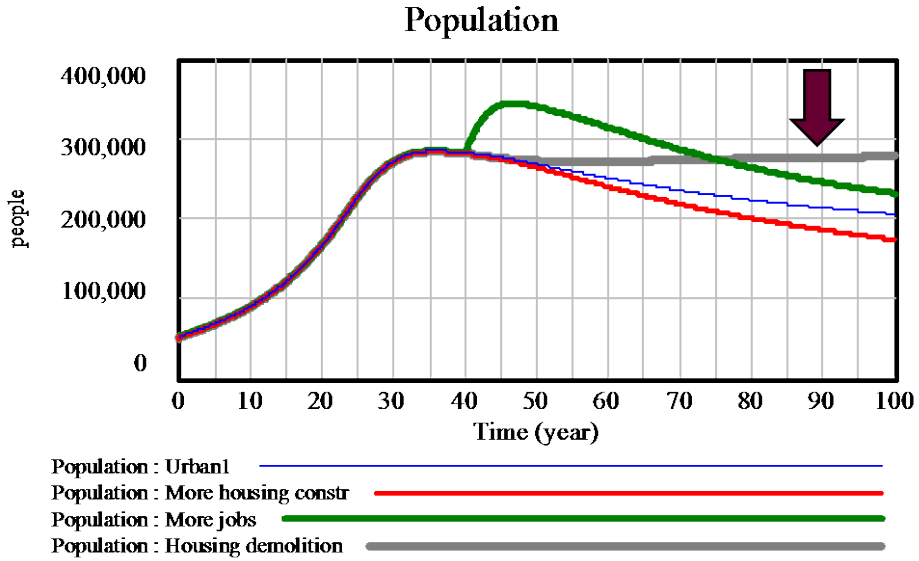


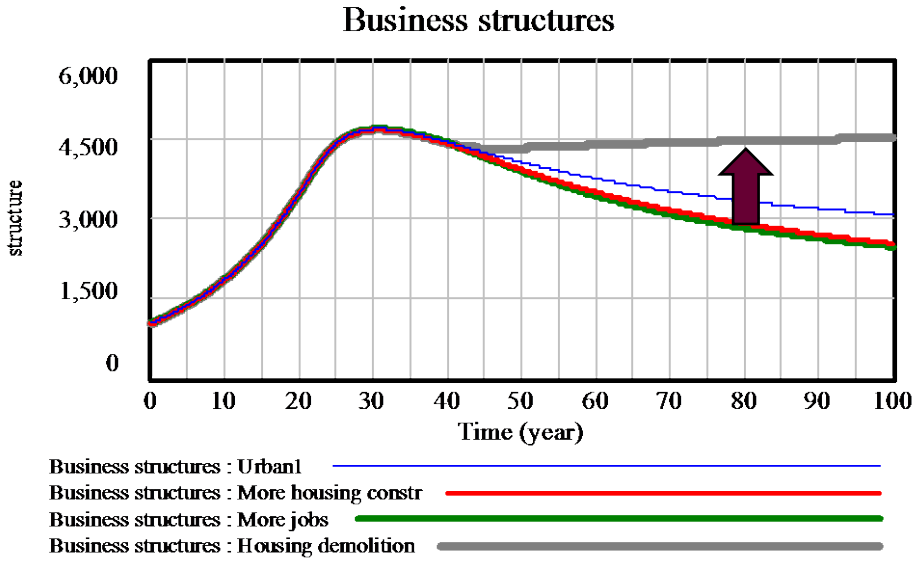
Short run benefit, no long run effect



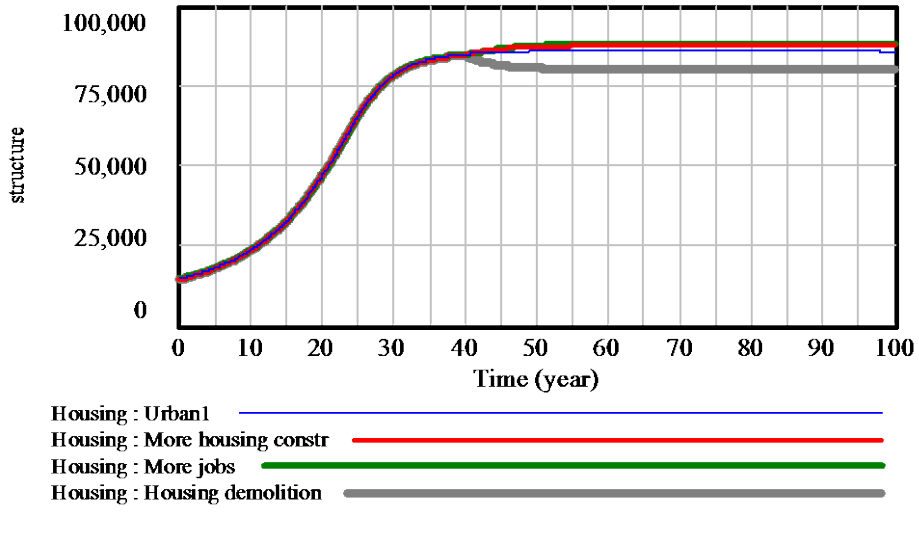


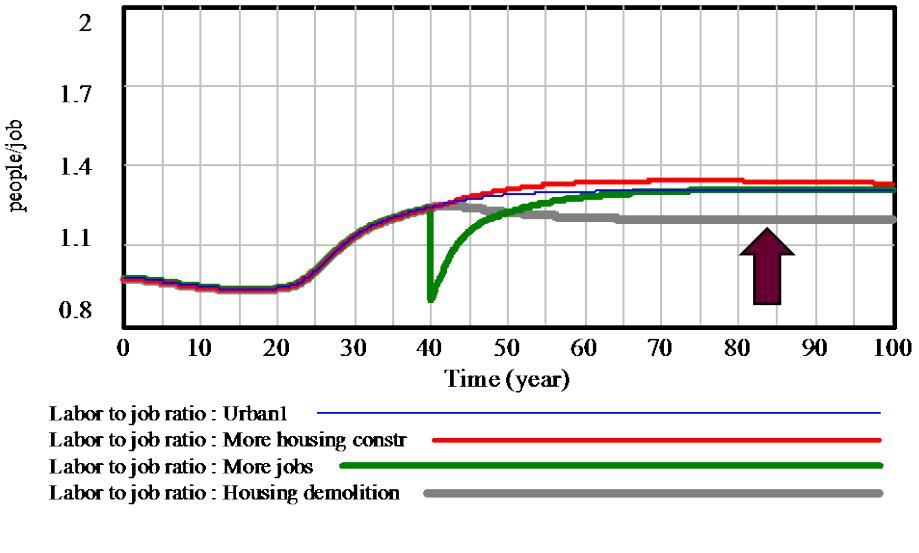
Housing demolition ($t \geq 40$)



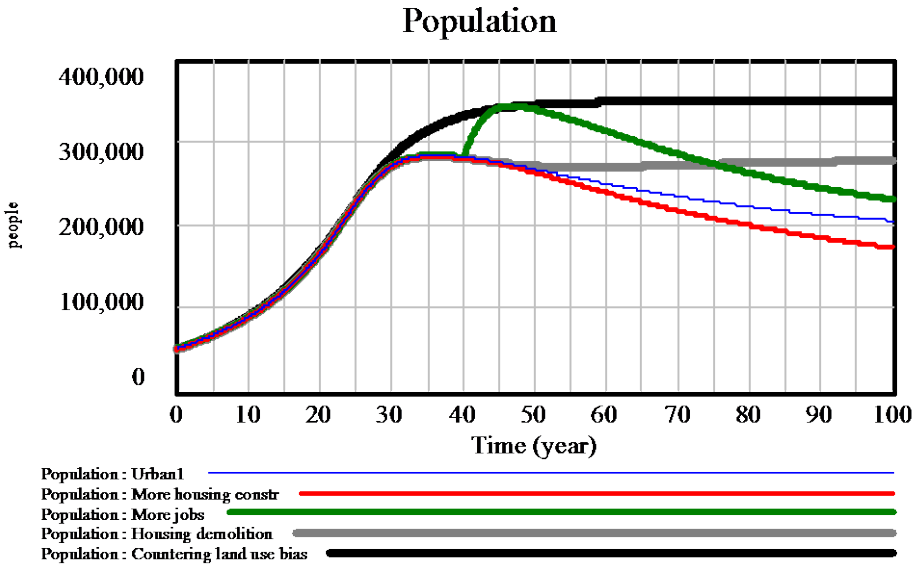


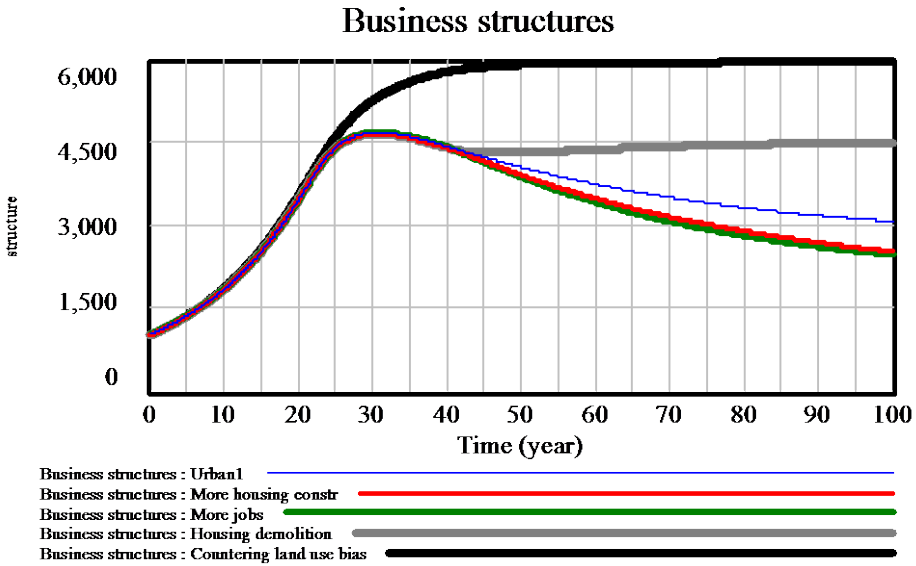
Makes things better! Why?



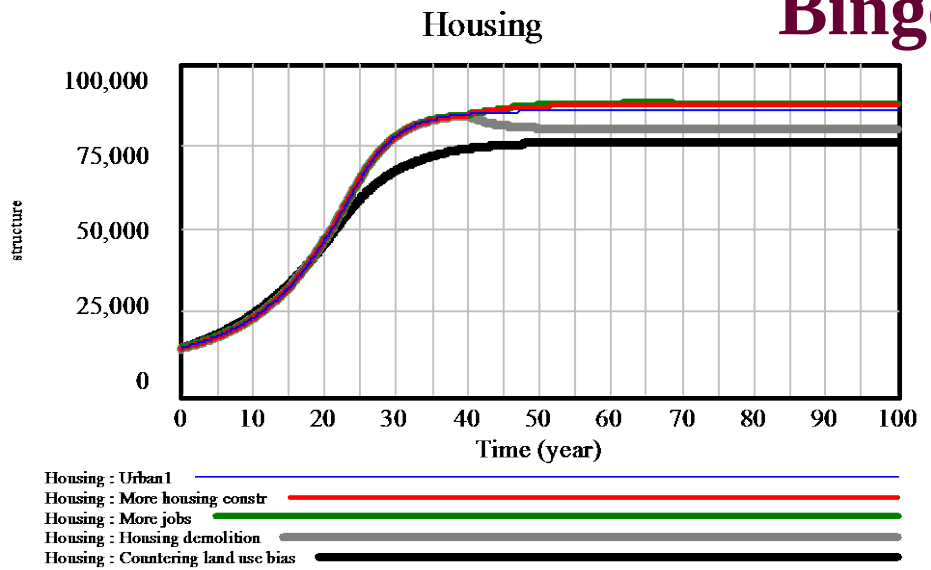


Eliminating Urban Decay

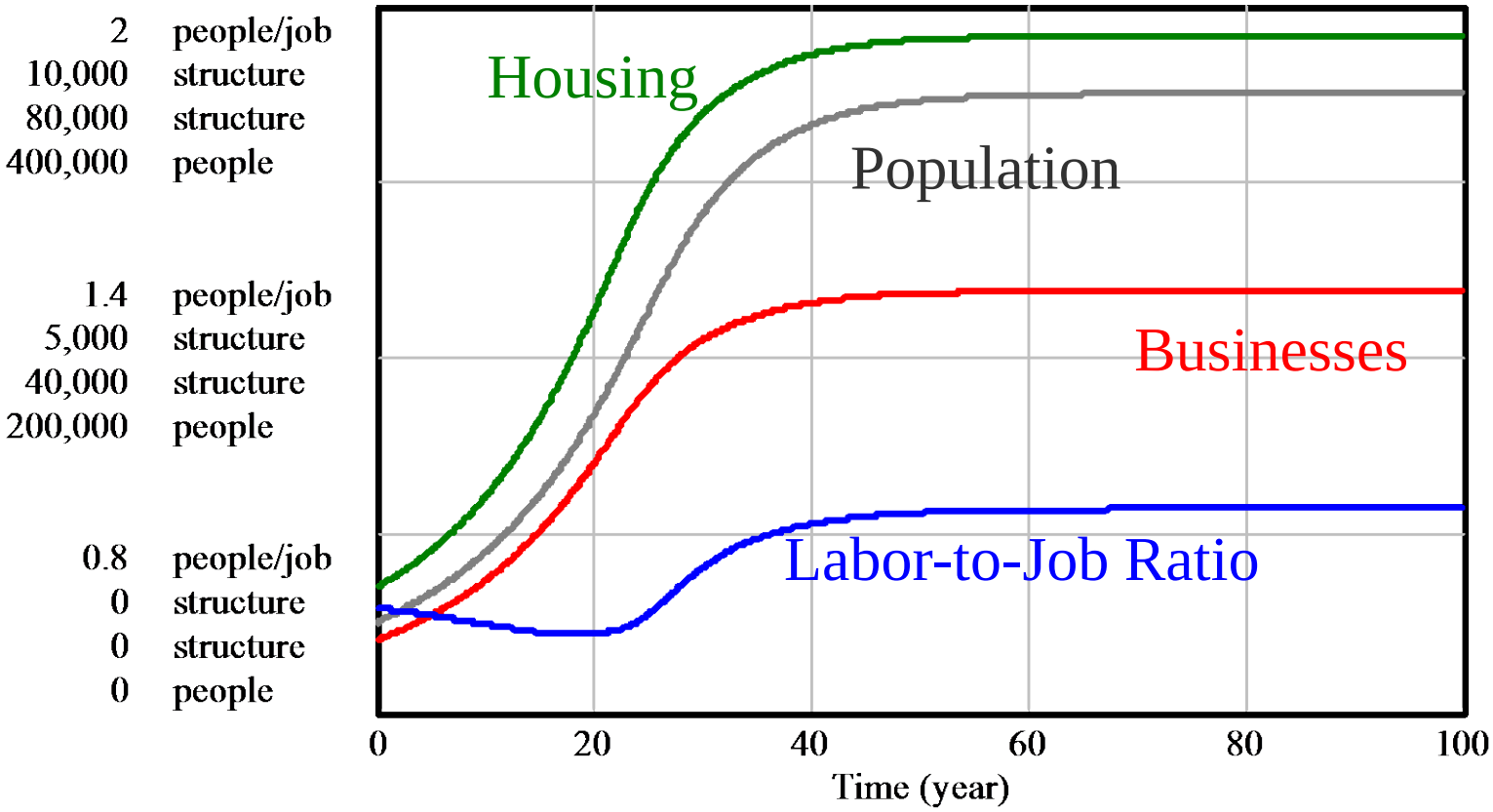




Bingo!



What policies prevent urban decay and improve long run employment?



Modeling the Spread of Diseases

Modeling Epidemics

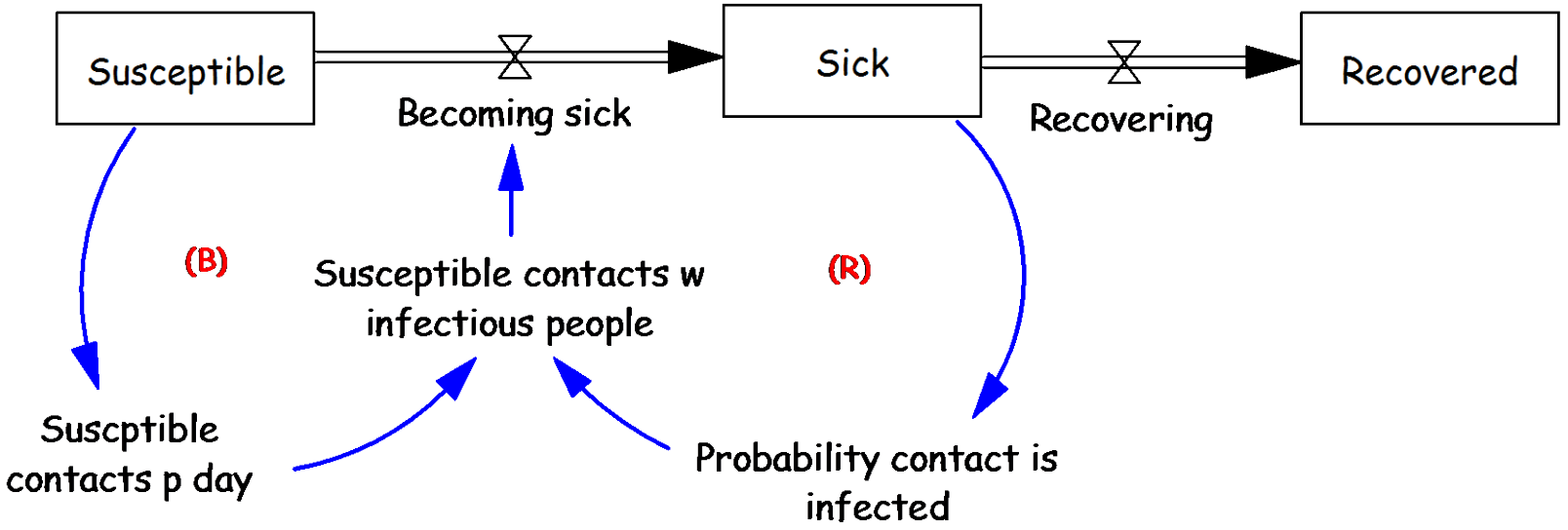
- Influenza
- HIV / AIDS
- Childhood diseases
- Polio
- ...all examples of Epidemiology

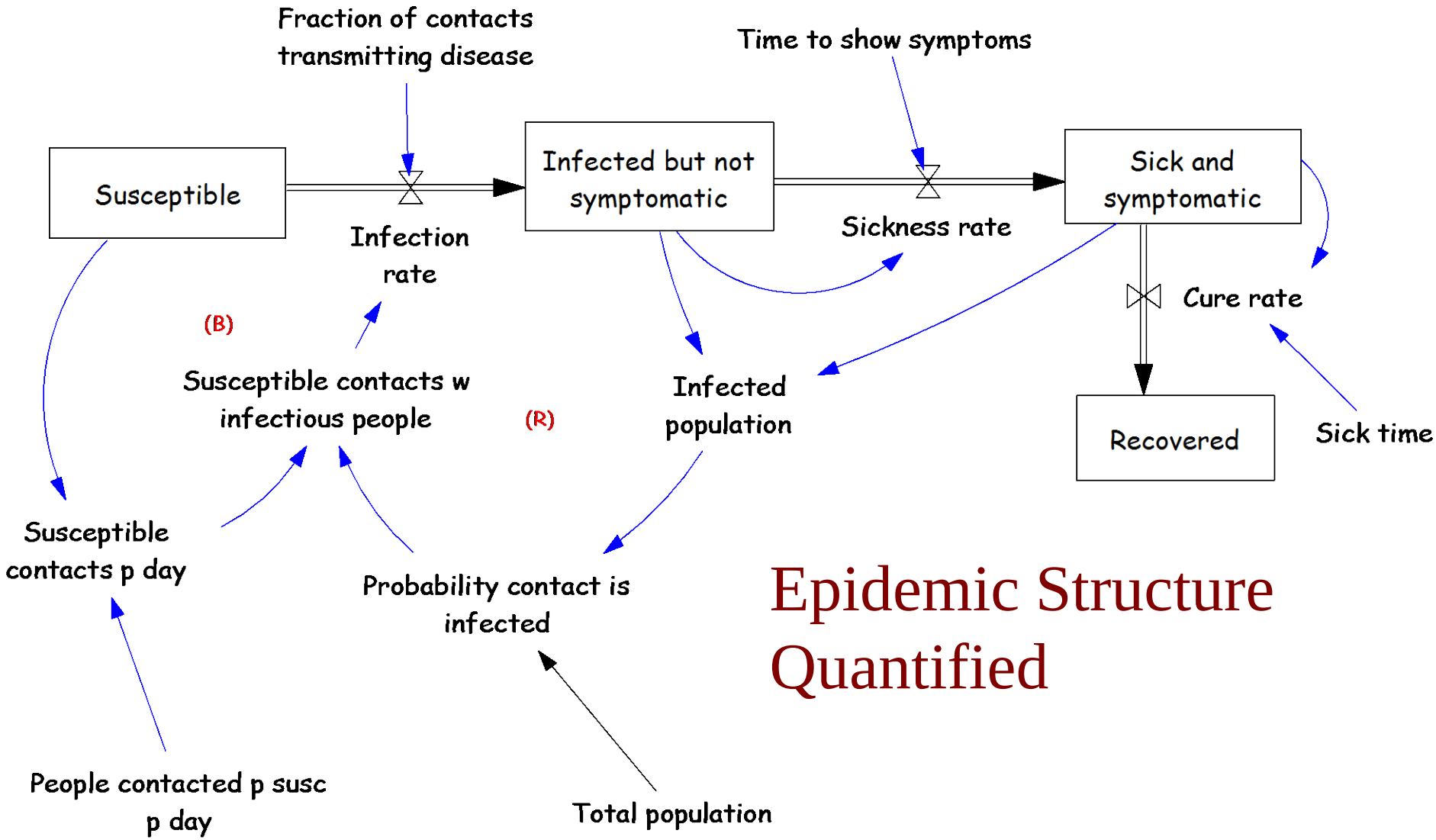
Polio Remains in Pockets Worldwide

Eradicating polio in India
Polio, a disease that has blighted the lives of millions, has almost been wiped out, but stubborn areas of resistance remain. Eradicating the disease in India is seen as the key to a polio-free world.

http://www.guardian.co.uk/world/gallery/2009/nov/27/polio-vaccination-india#/

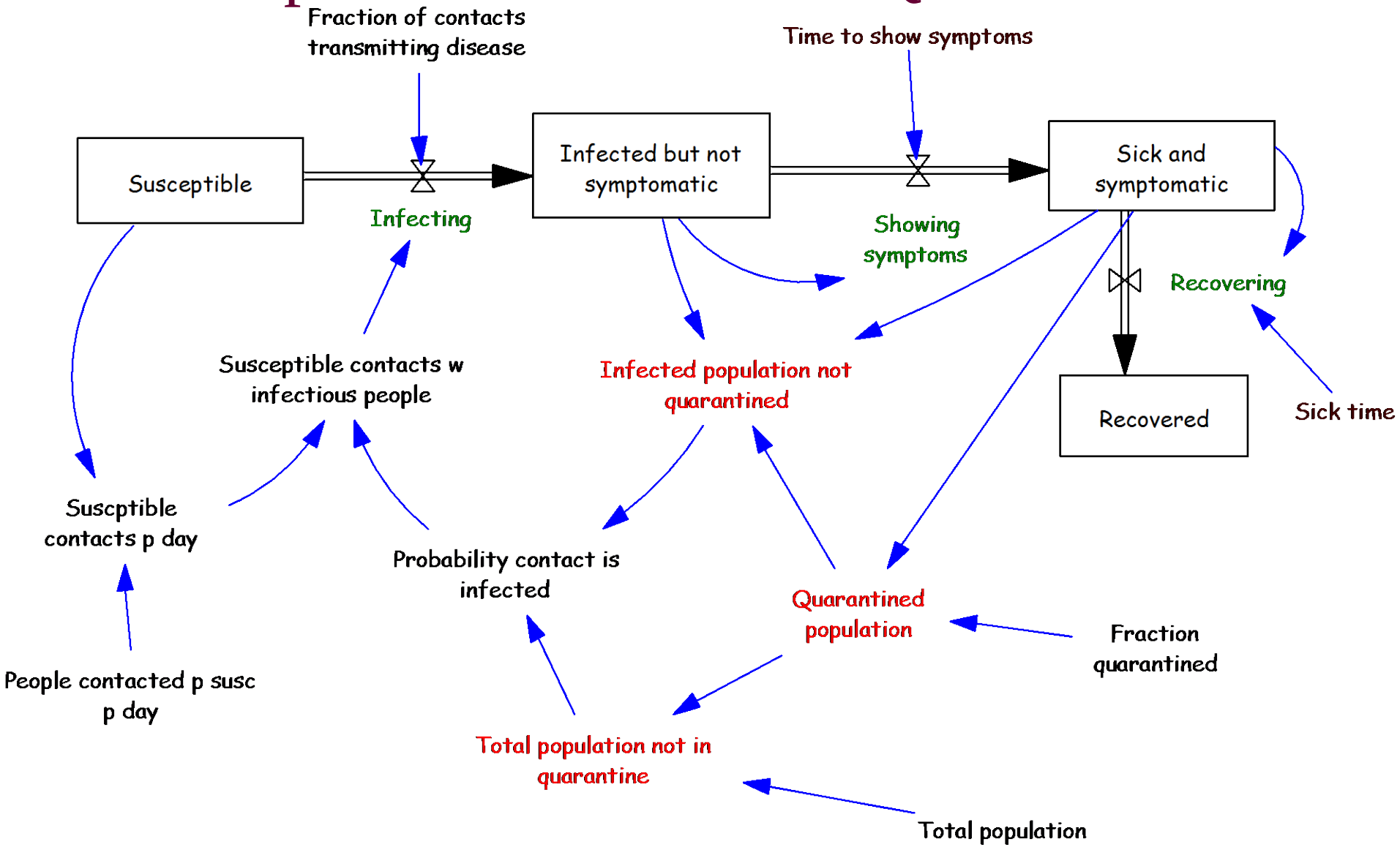
Core Structure of Infectious Diseases



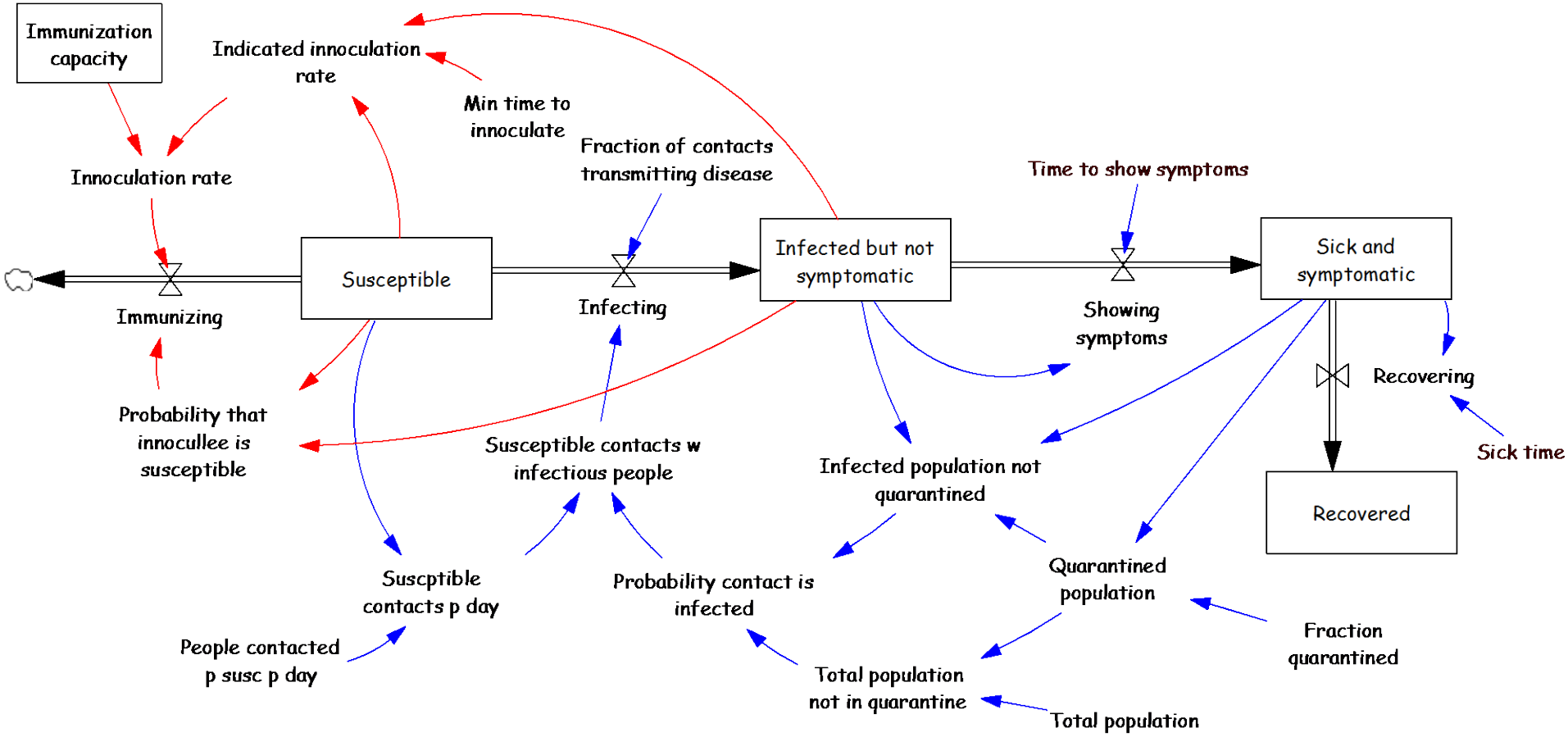


Epidemic Structure Quantified

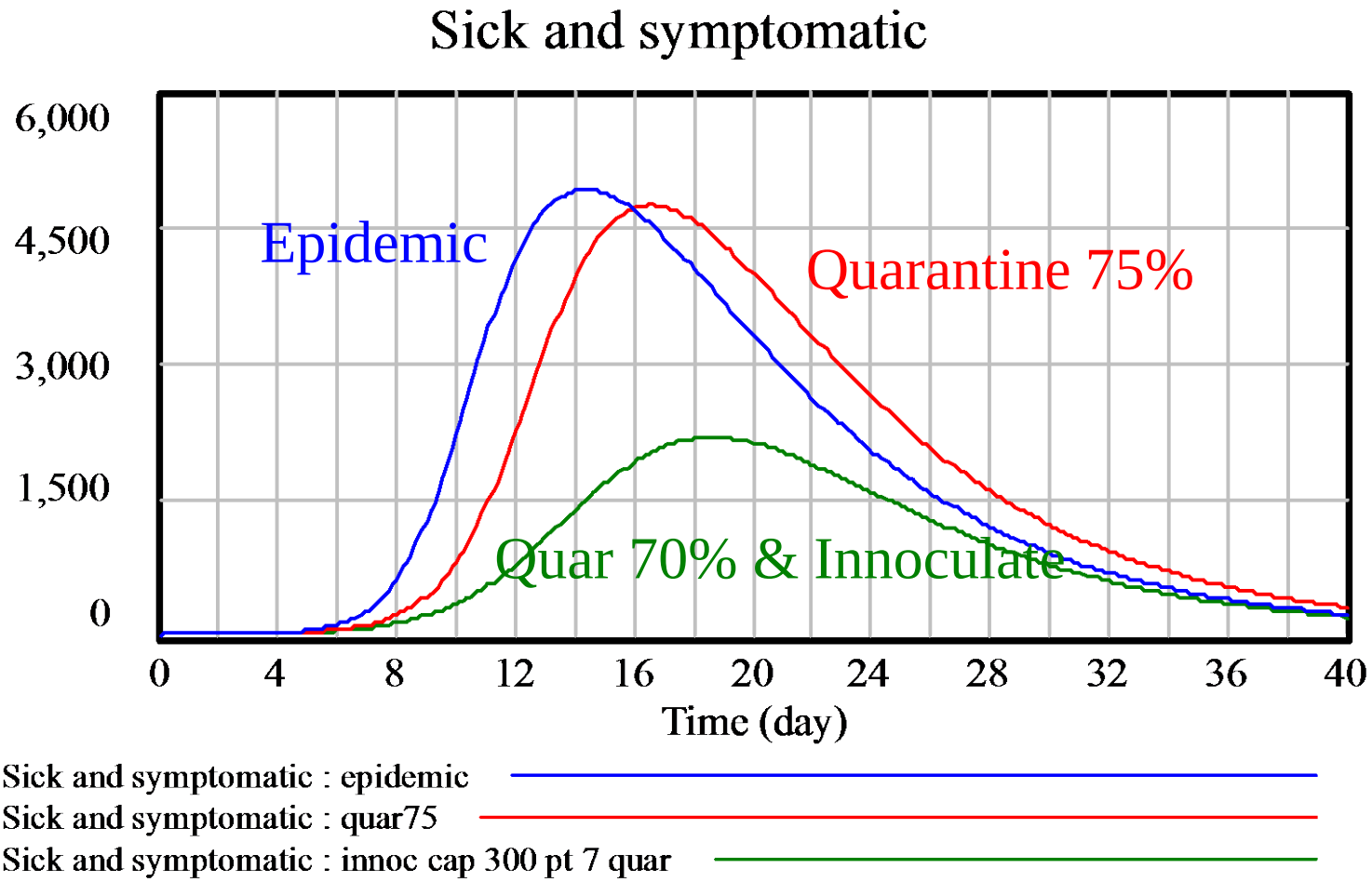
Epidemic Model with Quarantine



Epidemic Model with Quarantine & Inoculation



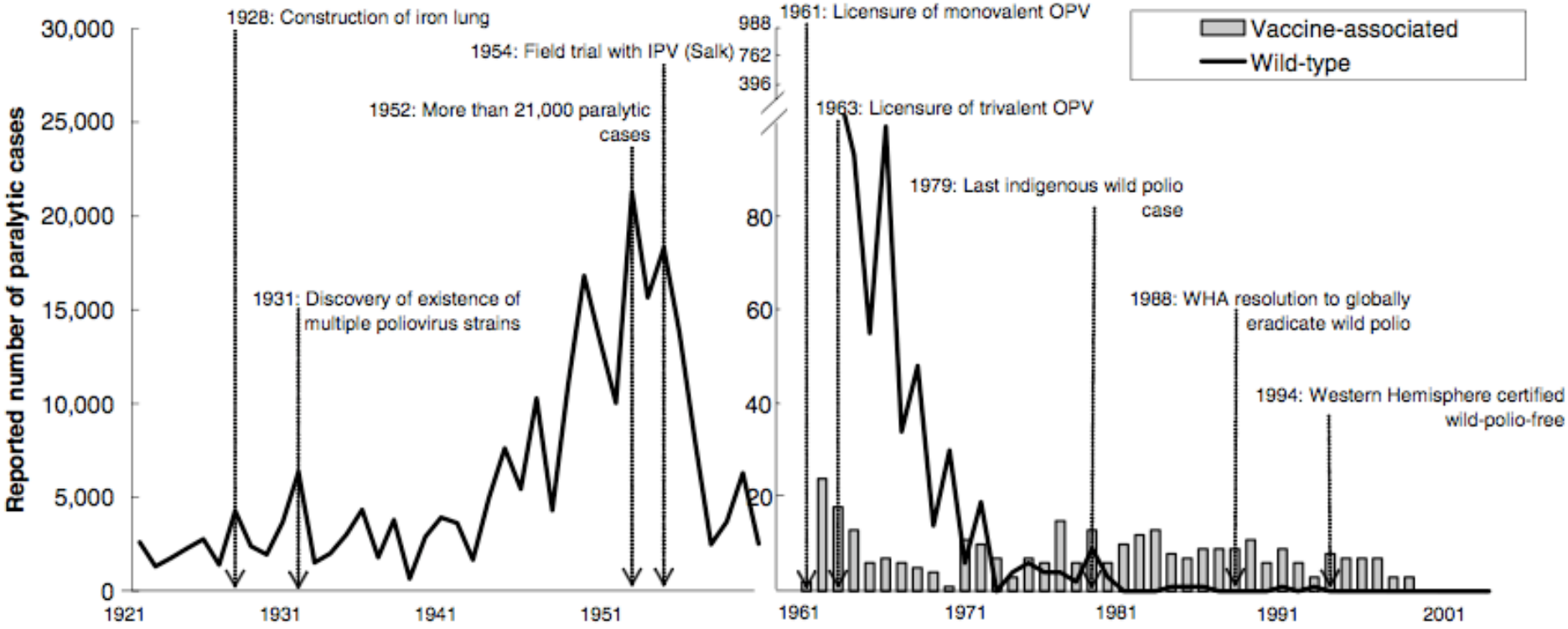
Comparing & Combining Policies



Eradication of Polio Worldwide

- Kimberly M. Thompson and Radboud J. Duintjer Tebbens. “Eradication Versus Control for Poliomyelitis: an Economic Analysis” *The Lancet* 369,9570 (April 2007): 1363-137.
- Winners of the Forrester Award from the System Dynamics Society in 2008.
- Thompson and her colleagues persuaded the World Health Organization to change its global polio strategy from containing outbreaks to eradication!

Poliomyelitis Before and After Vaccines

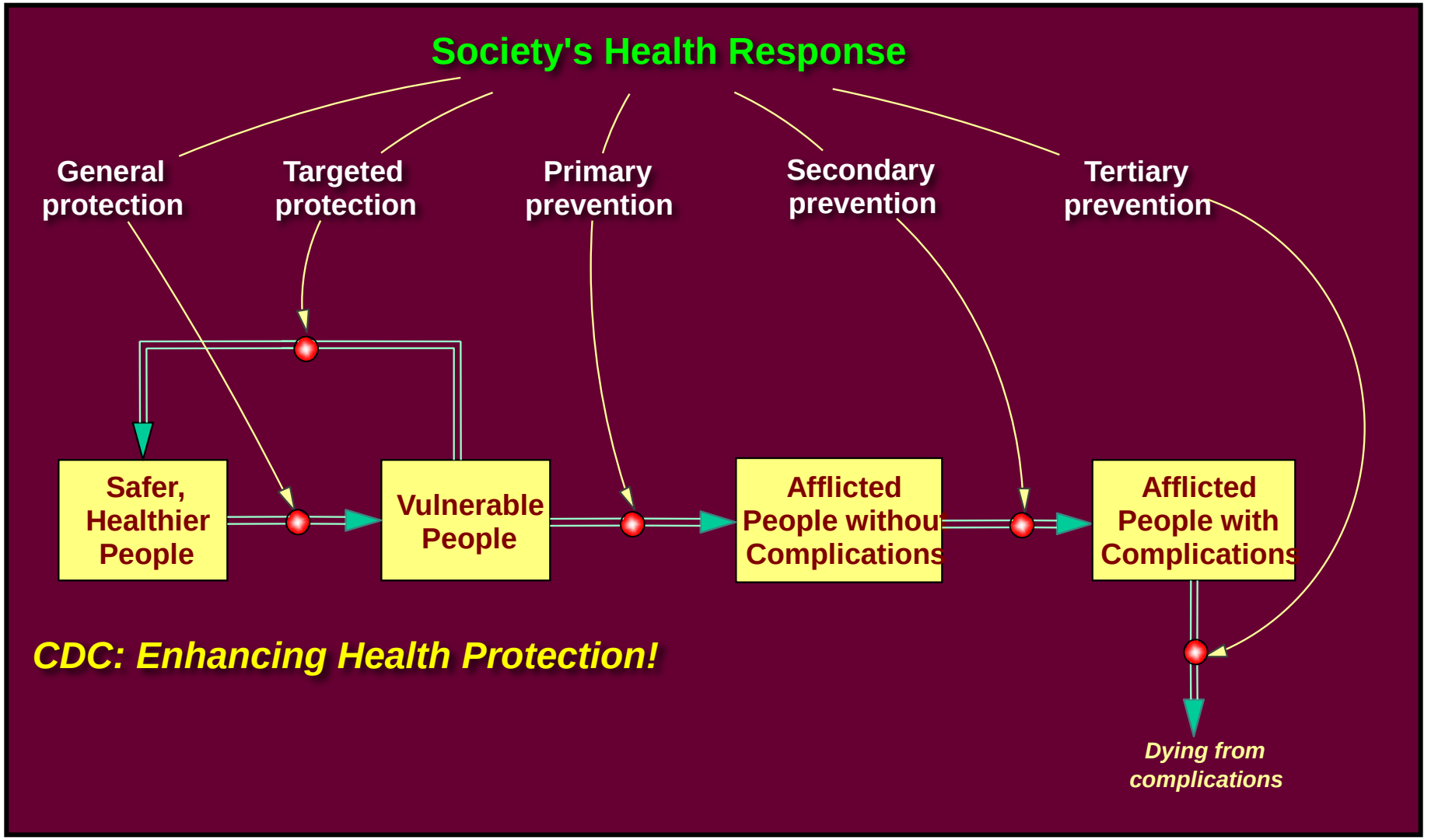


Source: Thompson and Tebbens (2006)

Eradication of Polio Worldwide

- "Downplaying the modeling to focus on the policy questions played a critical role in the use of the results by decision makers."
  - Thompson & Tebbens, Using system dynamics to develop policies that matter: global management of poliomyelitis and beyond. *System Dynamics Review* 24, 4 (winter 2008): 433-449.

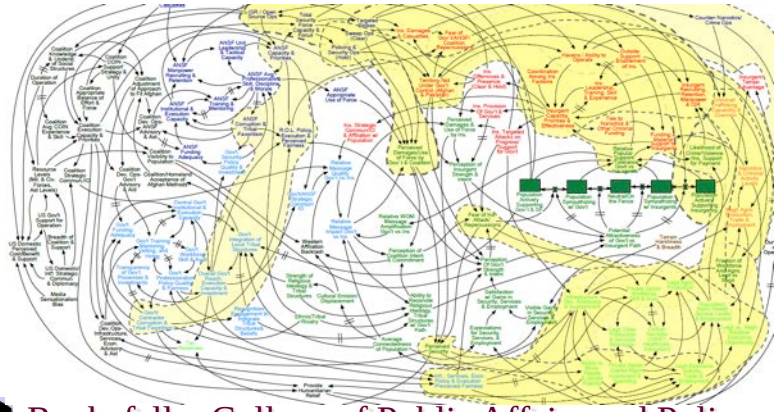
CDC View of Stocks in Future Health Priorities



And there are many more, of course...

More Impactful Applications

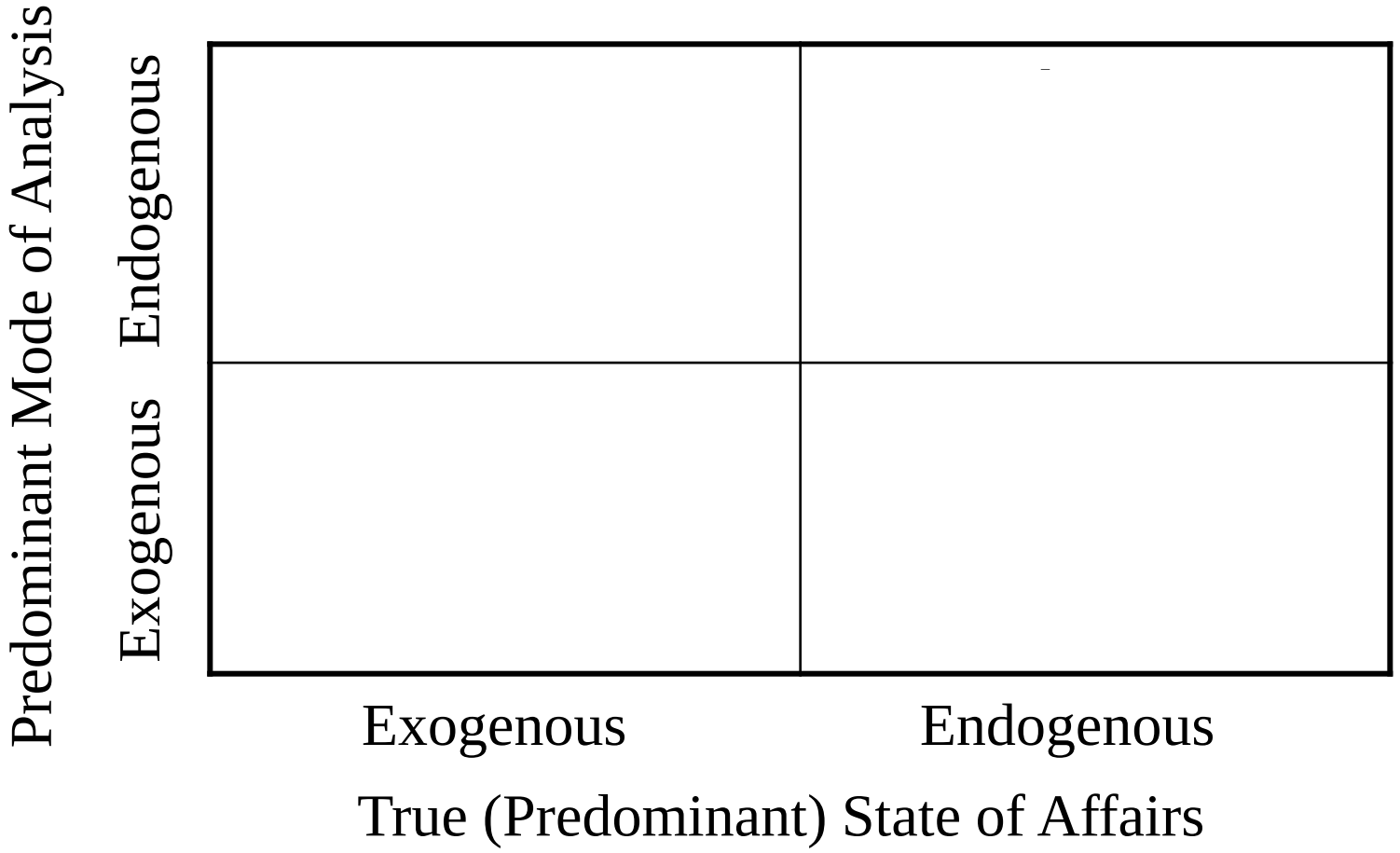
- Flood mitigation
- Climate modeling and global temperature dynamics
- Welfare reform in the United States
- Afghanistan counter-insurgency dynamics and policy
- Model-based health care policy studies...



What Creates Impact

- Significant problem
- Clear dynamic problem definition
- Stakeholder involvement
- Multiple perspectives
- "Requisite" modeling: what's necessary, and no more
- Large models for confidence, small models for understanding
  - Modeler usually builds small to large (like examples in this presentation)
  - Audience usually experiences large to small
- Powerful, insightful, sensitive, inquiring communication
- Endogenous perspective

The "X/N" Matrix



The Policy Resistance of Complex Systems