Why bicycle helmet laws backfire: Modelling the temporal dynamics of safety-in-numbers

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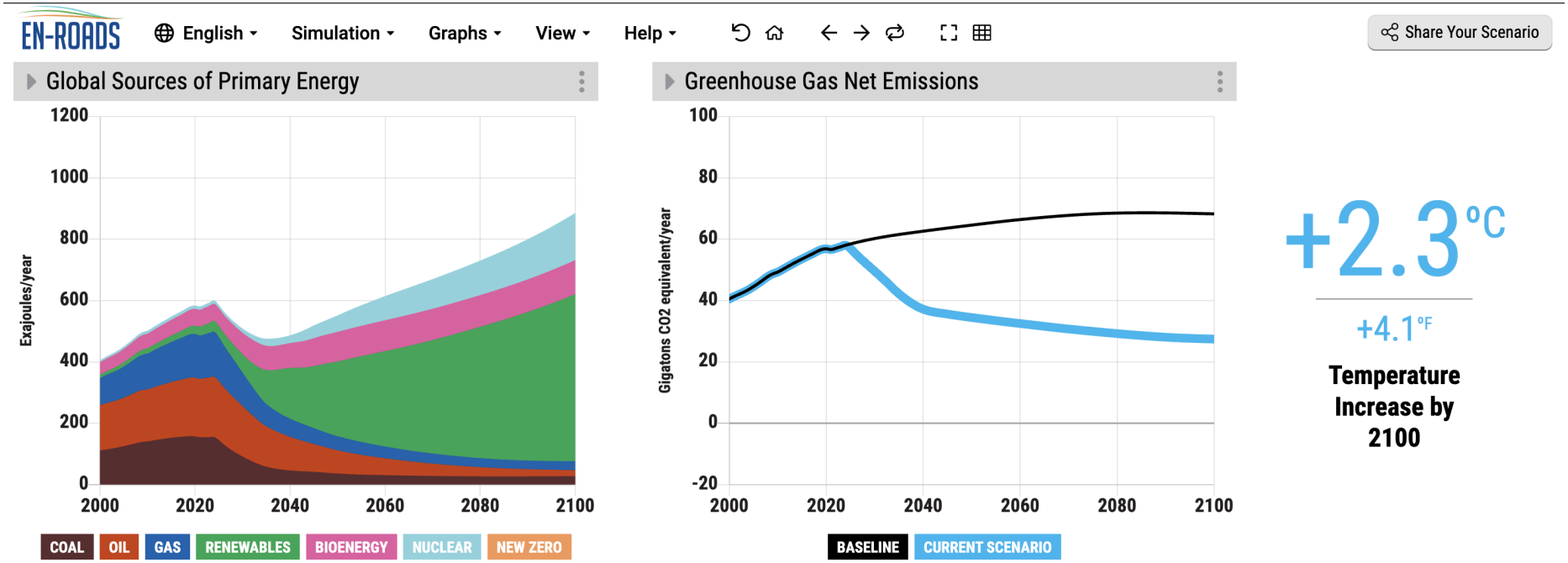
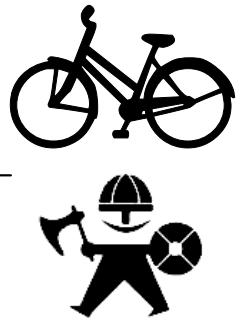
C-MUS
2024-09-23


EN-ROADS
English
Simulation
Graphs
View
Help
Share Your Scenario
Global Sources of Primary Energy
Exajoules/year
1200
1000
800
600
400
200
0
2000
2020
2040
2060
2080
2100
COAL
OIL
GAS
RENEWABLES
BIOENERGY
NUCLEAR
NEW ZERO
Greenhouse Gas Net Emissions
Gigatons CO2 equivalent/year
100
80
60
40
20
0
-20
BASELINE
CURRENT SCENARIO
+2.3°C
+4.1°F
Temperature Increase by 2100
Energy Supply
Coal
very highly taxed
Renewables
highly subsidized
Oil
very highly taxed
Nuclear
highly subsidized
Natural Gas
very highly taxed
New Zero-Carbon
status quo
Bioenergy
highly subsidized
Carbon Price
very high
Transport
Energy Efficiency
increased
Electrification
highly subsidized
Buildings and Industry
Energy Efficiency
increased
Electrification
subsidized
Growth
Population
status quo
Economic Growth
high growth
Carbon Dioxide Removal
Nature-Based
low growth
Technological
low growth
Other Sources of Greenhouse Gases
Agricultural Emissions
status quo
Waste and Leakage
status quo
Deforestation
status quo
CLIMATE INTERACTIVE
MIT MANAGEMENT SLOAN SCHOOL
Register Your En-ROADS Event

Transportation policy $\rightarrow$ *intrinsic good*

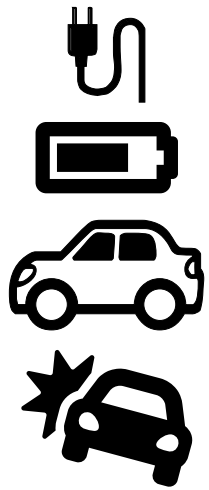
Objective	Correlate	Mechanisms	Technology

Wellbeing $\leftarrow$ { **Lifespan**, QALY, DALY, LEGPH, Gini, SDGs, $\vdots$ } $\leftarrow$ { **Active lifestyle**, **Mobility safety**, **Clean air**, Mobility equity, Child cognitive development, Reduced parental burdens, Pleasant "third space", Economic efficiency, Low resource use, Stable biosphere, Stable climate, Global equity, $\vdots$ } $\leftarrow$



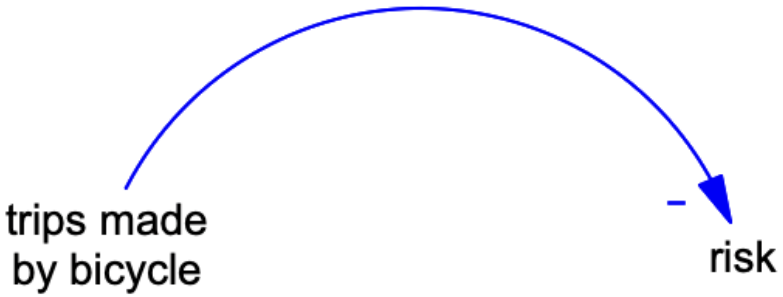
Transportation policy $\rightarrow$ *decarbonisation*

Objective	Correlate	Benefits	Technology
~~*Wellbeing*~~	~~**Lifespan**~~	~~**Active lifestyle**~~	
$CO_2 \downarrow$	~~QALY~~	~~**Mobility safety**~~	
Profit	~~DALY~~	Clean air	
	~~LEGPH~~	~~Mobility equity~~	
	~~Gini~~	~~Child cognitive development~~	
	~~SDGs~~	~~Reduced parental burdens~~	
	$\vdots$	~~Pleasant "third space"~~	
		~~Economic efficiency~~	
		~~Low resource use~~	
		~~Stable biosphere~~	
		Stable climate	
		~~Global equity~~	
		$\vdots$	



Biking $\leftrightarrows$ Safety-in-numbers

- More biking $\leftrightarrows$ safer biking
  - e.g. twice as many cyclists $\rightarrow \approx 35\%$ safer
- Active mobility $\rightarrow$ health!



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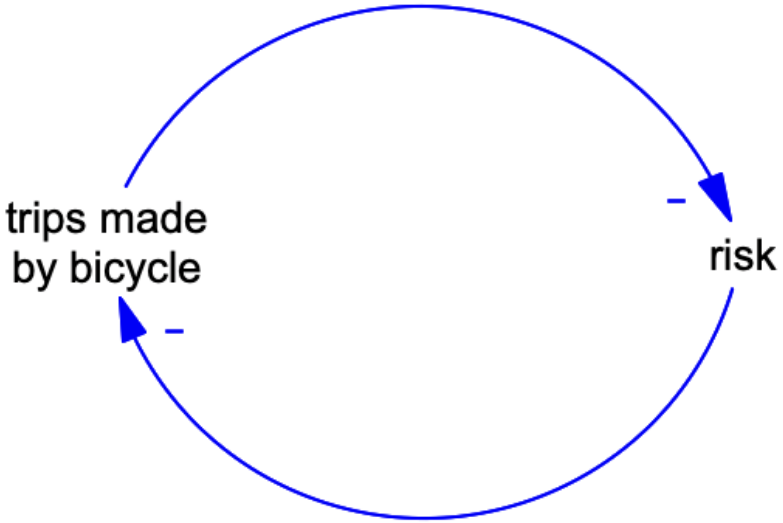

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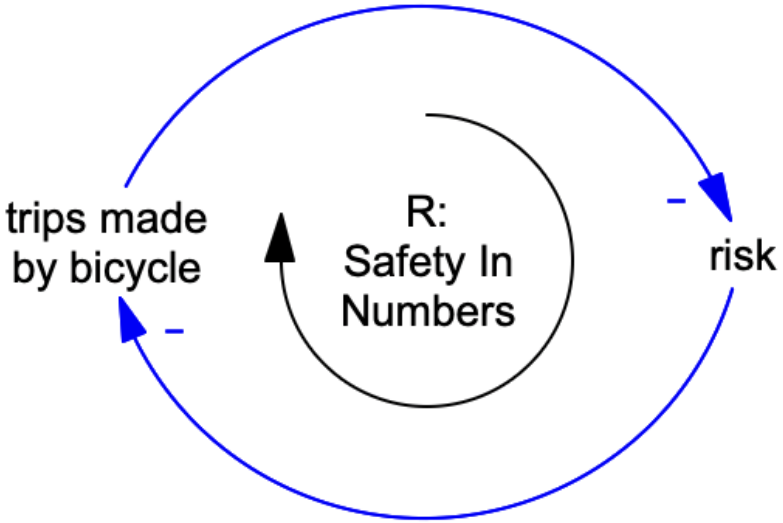

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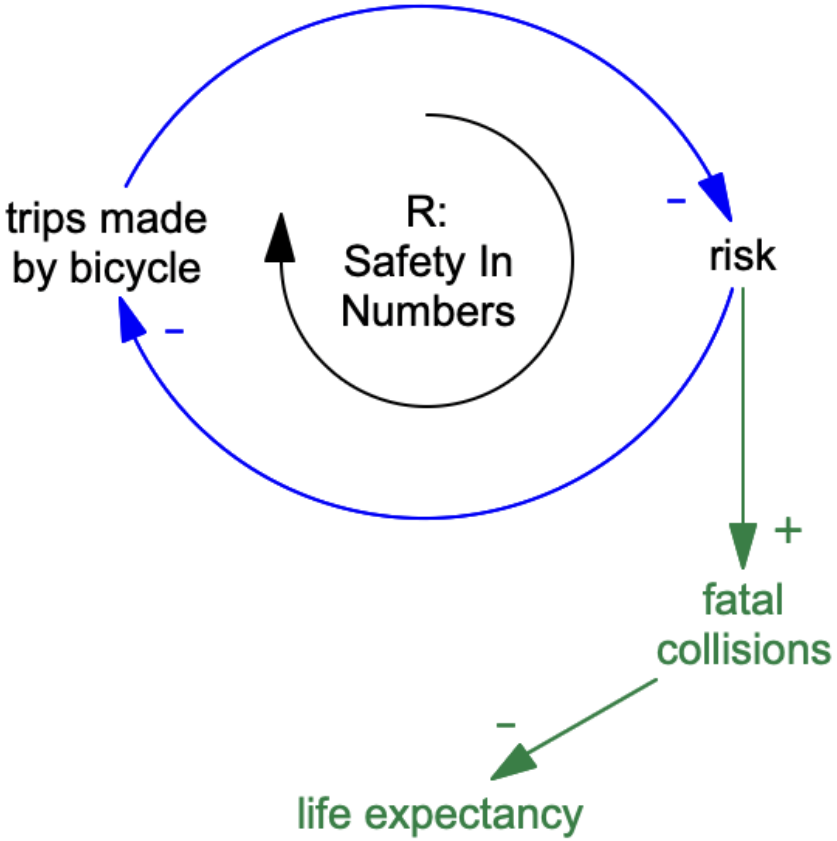

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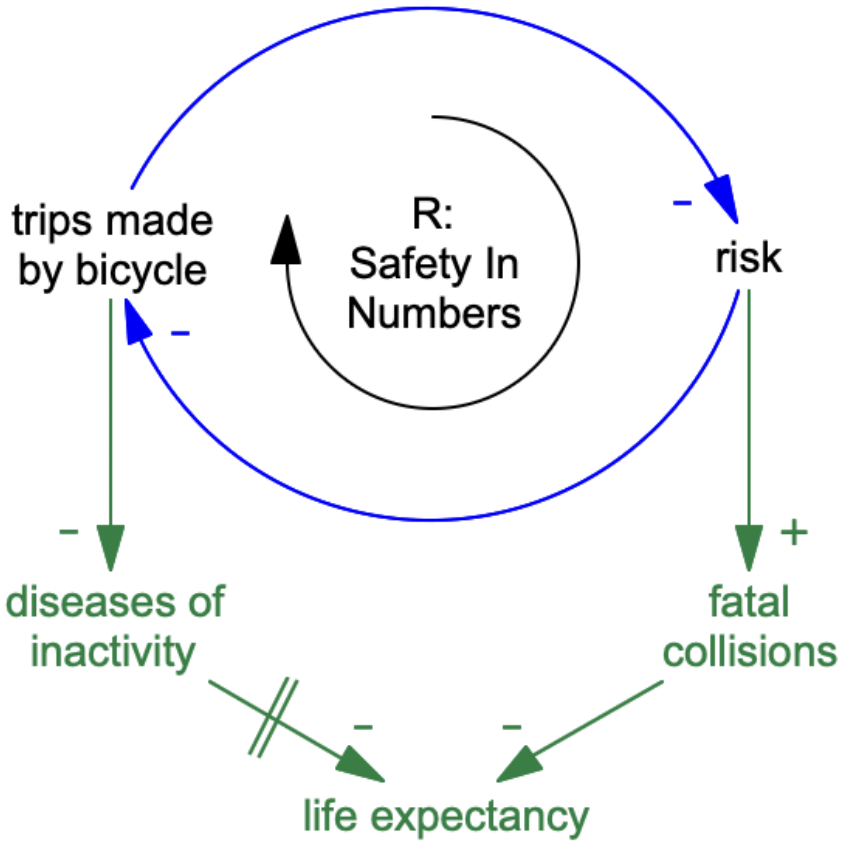
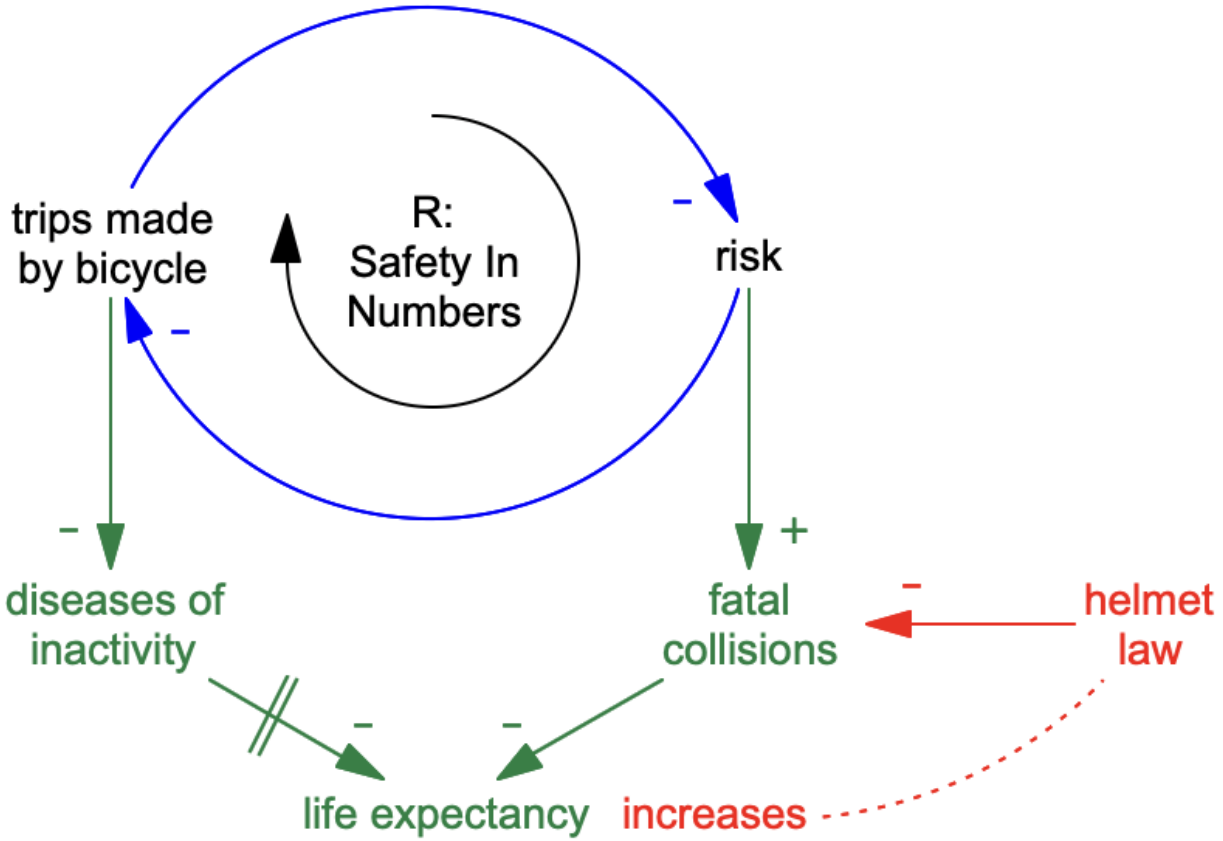


Helmet laws

- Reduce deaths in collisions
- Reduce safety-in-numbers effects
  - e.g. driver awareness, infrastructure improvements. . .



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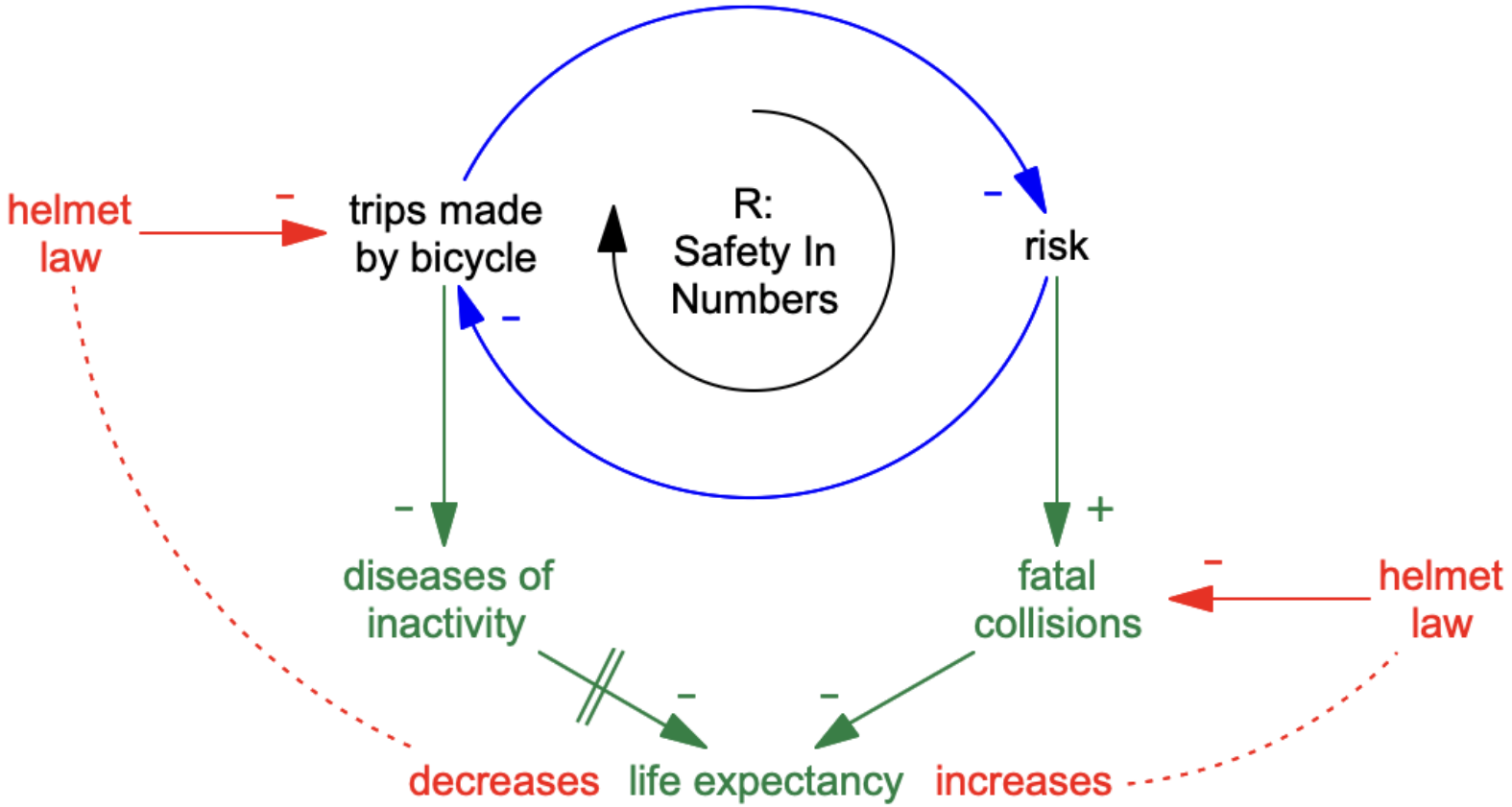
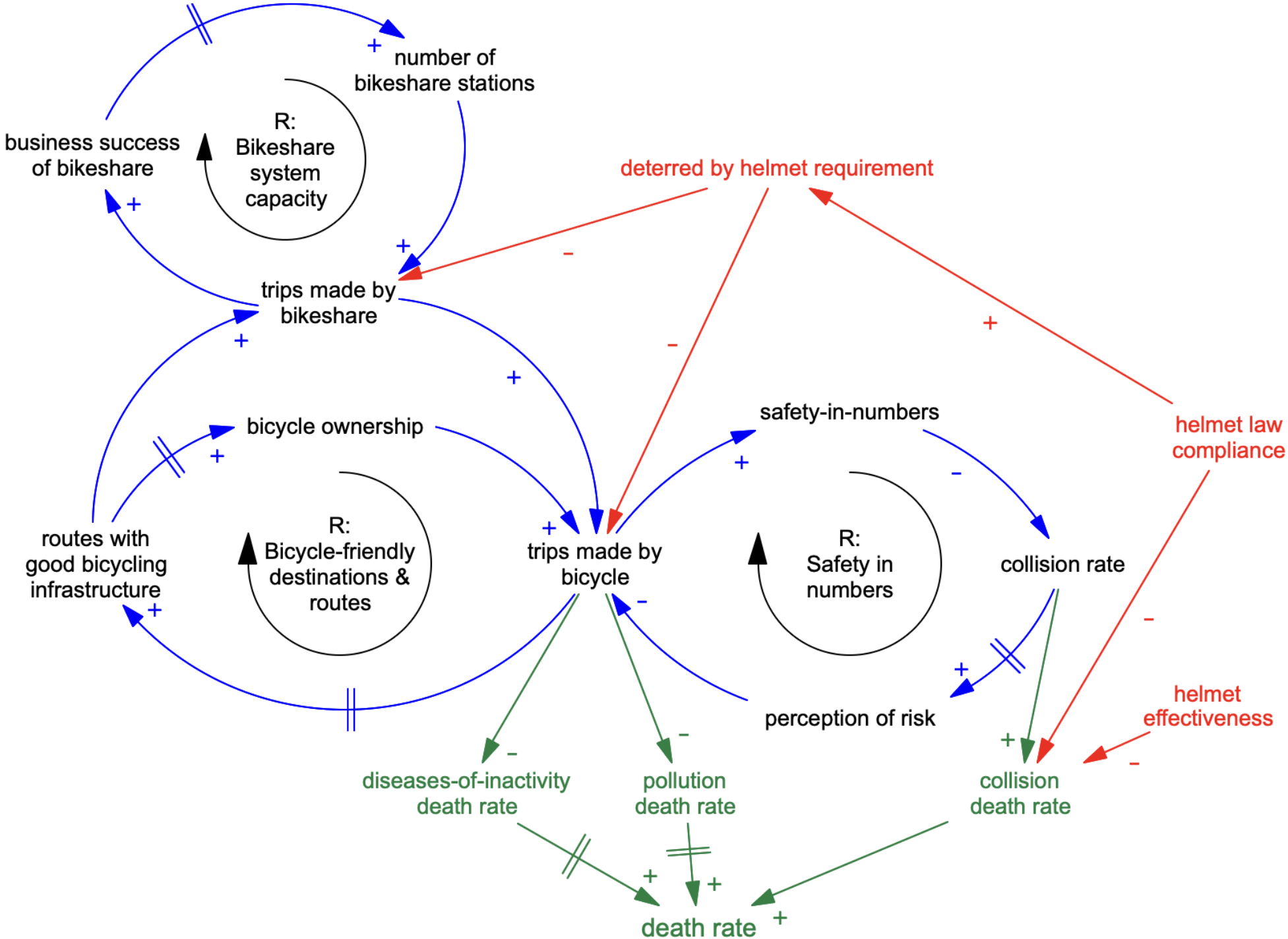
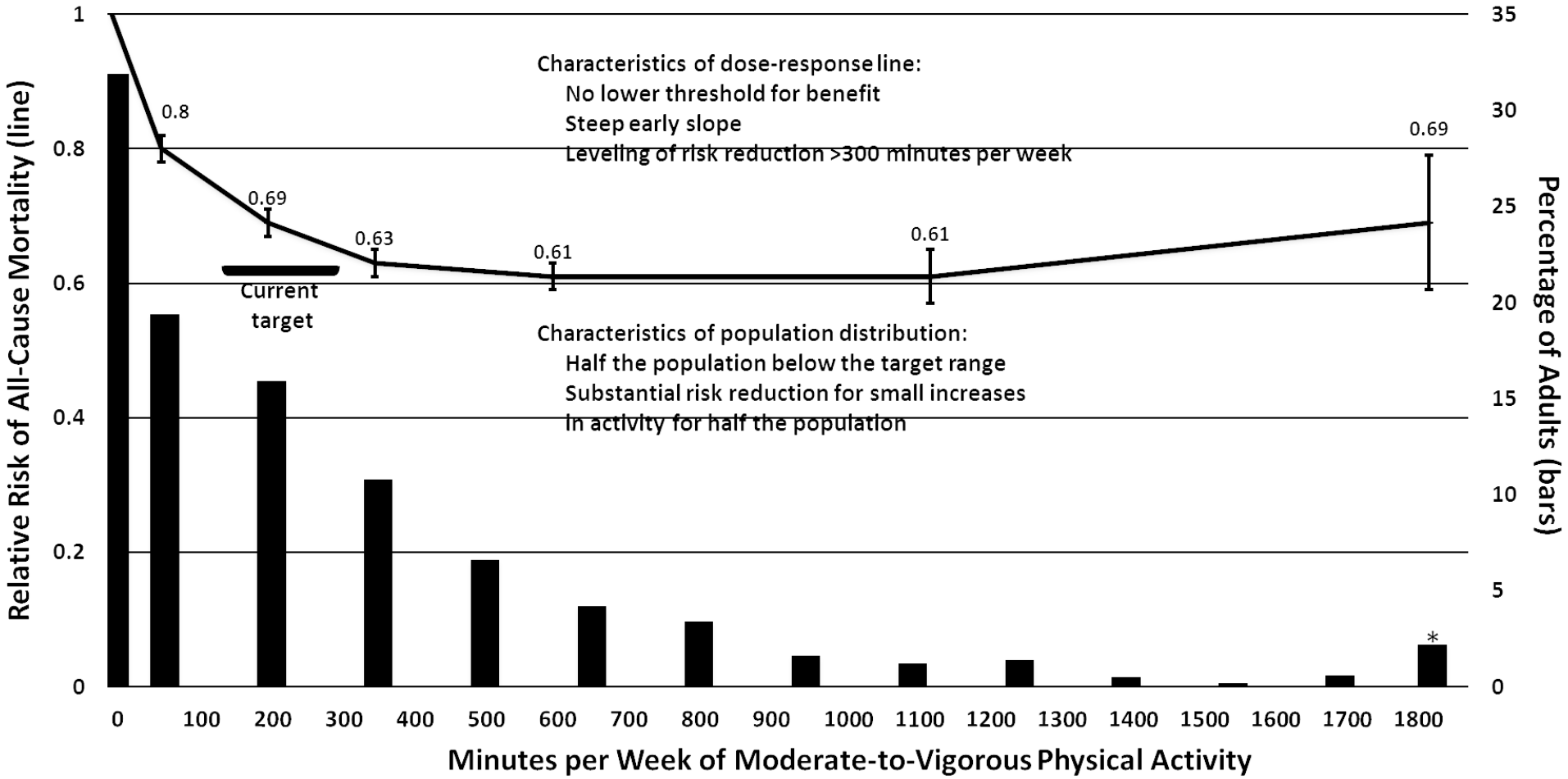



number of bikeshare stations
business success of bikeshare
R: Bikeshare system capacity
deterred by helmet requirement
trips made by bikeshare
bicycle ownership
safety-in-numbers
helmet law compliance
routes with good bicycling infrastructure
R: Bicycle-friendly destinations & routes
trips made by bicycle
R: Safety in numbers
collision rate
perception of risk
helmet effectiveness
diseases-of-inactivity death rate
pollution death rate
collision death rate
death rate

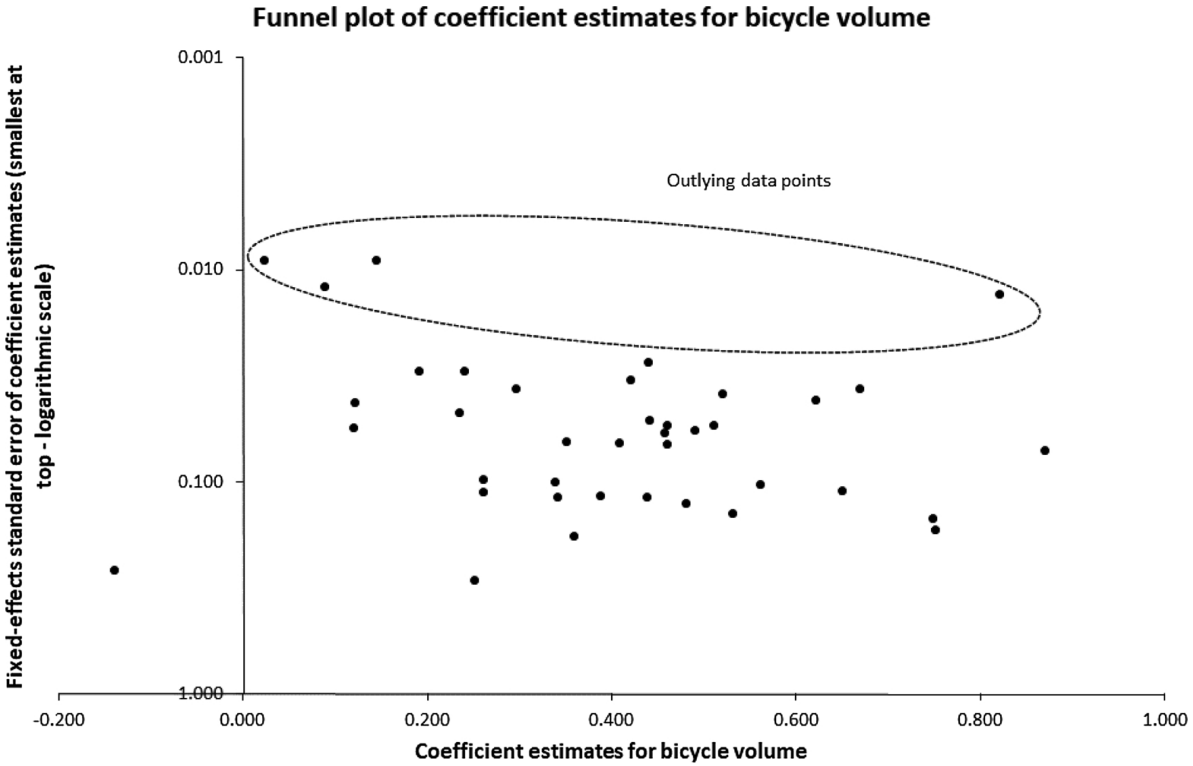
More biking → Greater lifespan, healthspan



[*2018 physical activity guidelines advisory committee scientific report.* Department of Health and Human Services]

More biking → Safer biking

- More biking $x \leftrightarrows$ safer biking: collisions $\propto (\Delta x)^{\beta}$
  - $\beta \approx [0.25 \ldots 0.4]$
  - risk $\propto \frac{(\Delta x)^{\beta}}{(\Delta x)} = (\Delta x)^{\beta - 1}$
  - e.g. twice as many cyclists $\rightarrow \approx 35\%$ safer



[Elvik & Goel. *Safety-in-numbers: An updated meta-analysis of estimates.* Accident Analysis and Prevention, 2019]

Helmet requirements → Greater crash survivability

Great controversy on this topic, so:

Assume perfect helmets!

Helmet requirements → Less biking

Among owners: 10–40%

Bikesharing:

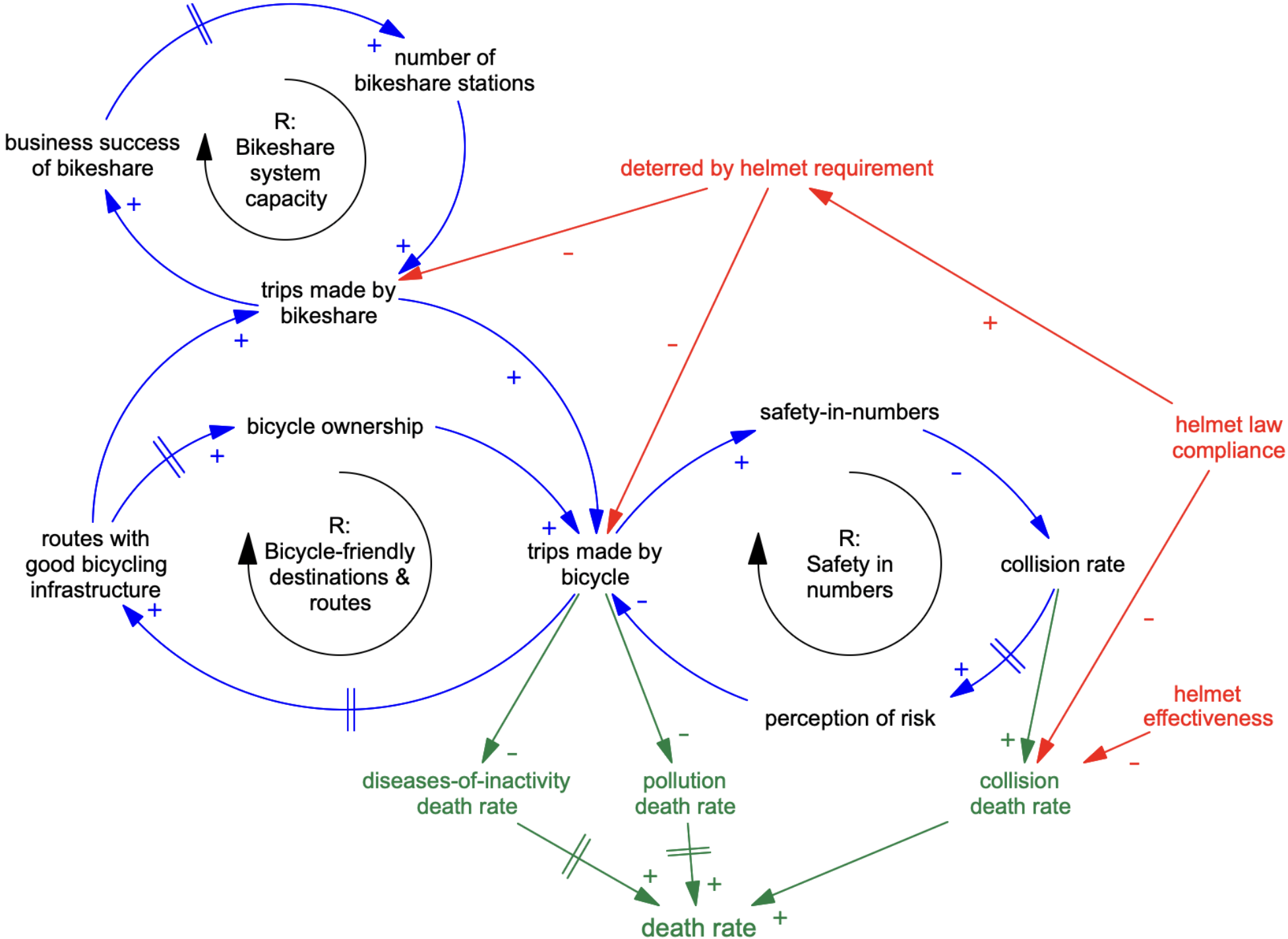
Frequent users: ?

Spontaneous trips: 80%?

New user recruitment: 90%???

- Poorly studied
- Much debated
- Lots of anecdotal evidence
- Some qualitative evidence

Biggest quantitative gap! But qualitatively OK.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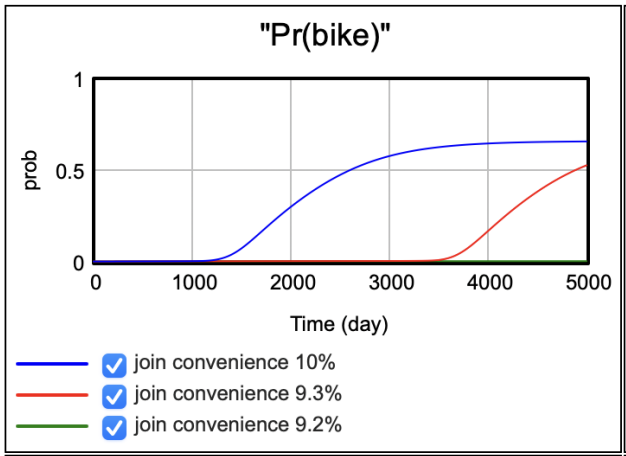
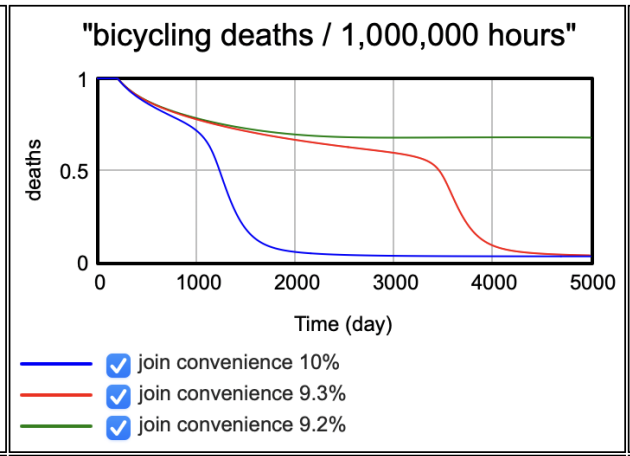
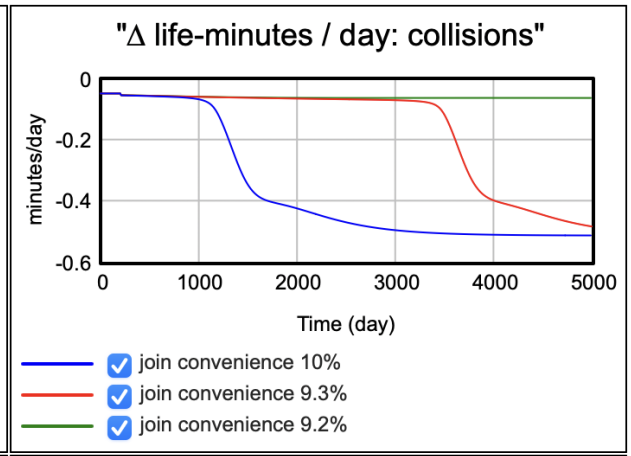
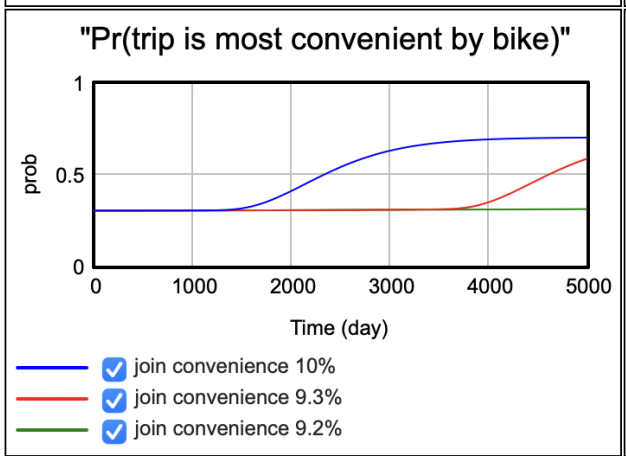
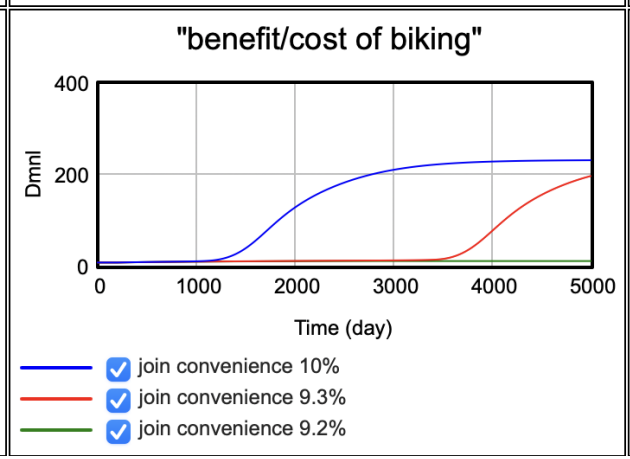
Introducing a bikeshare

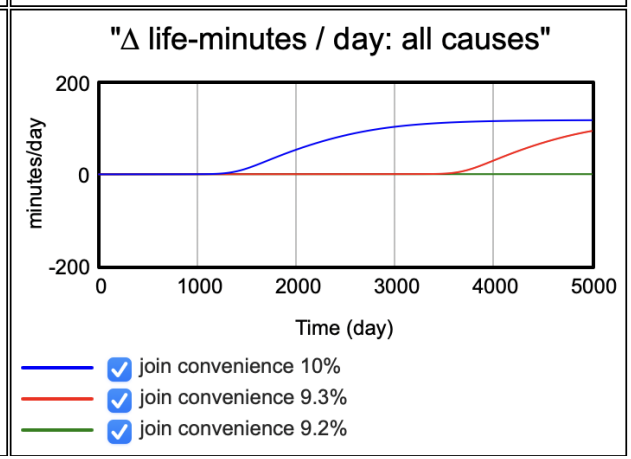




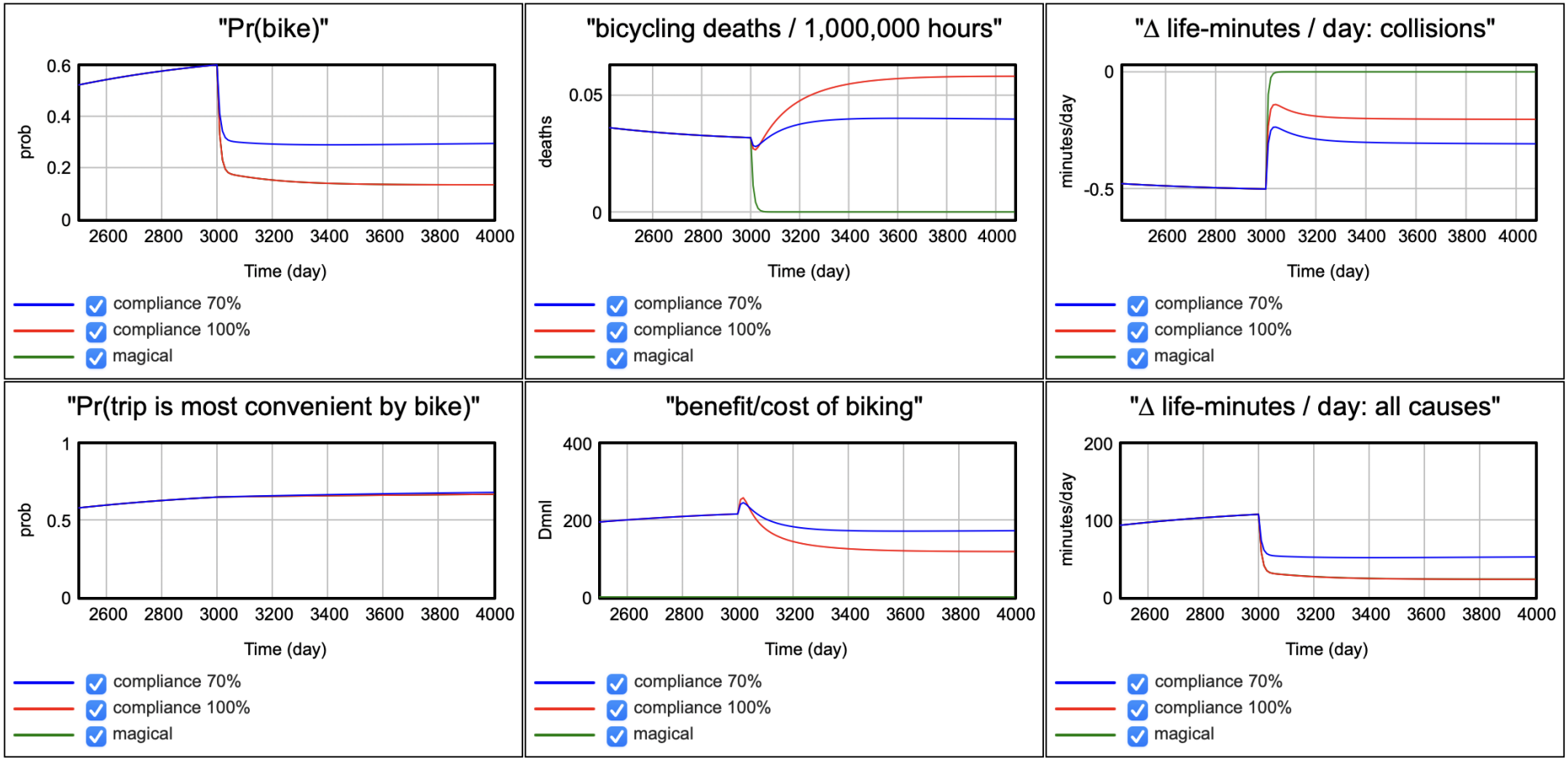




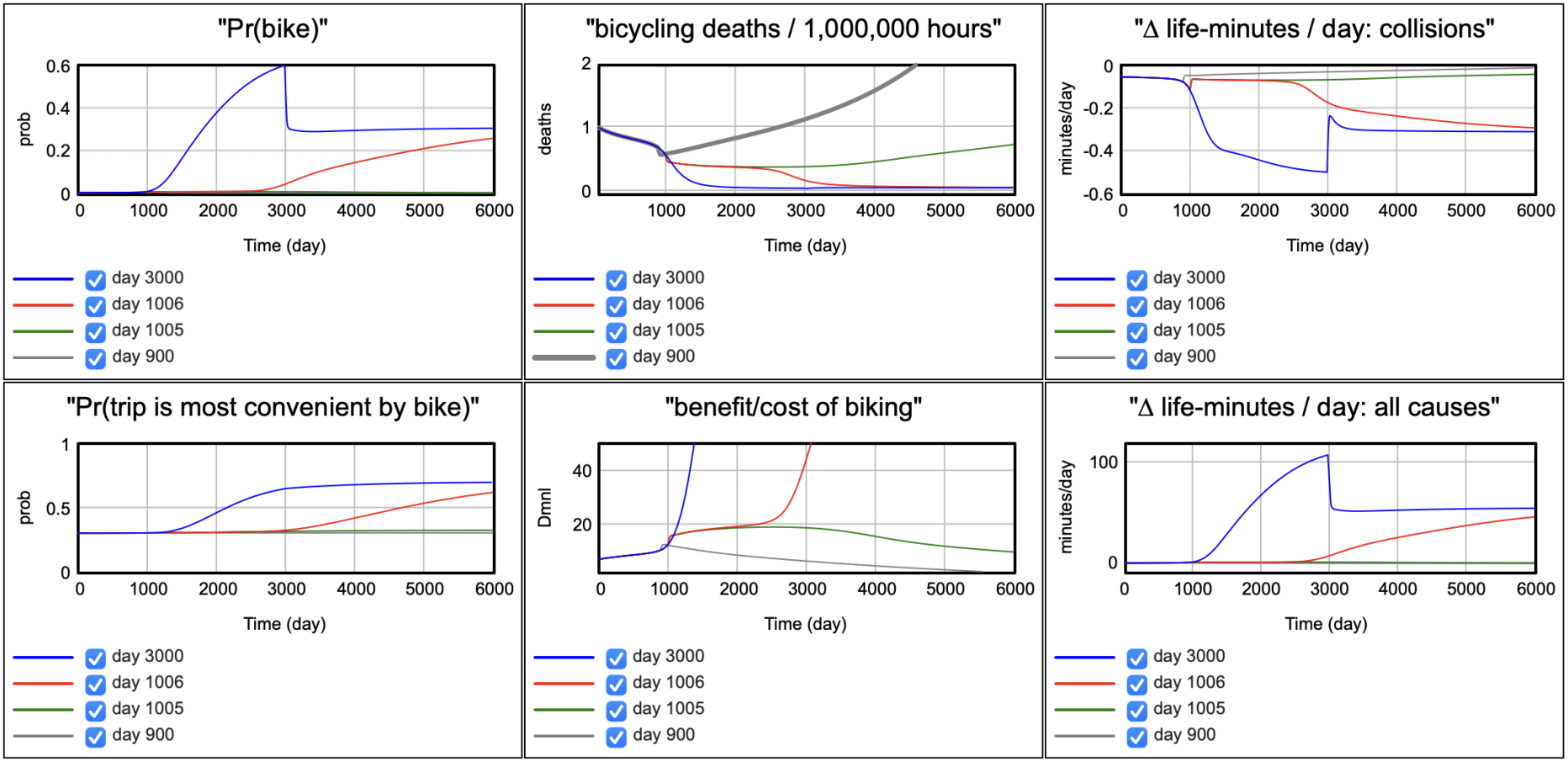




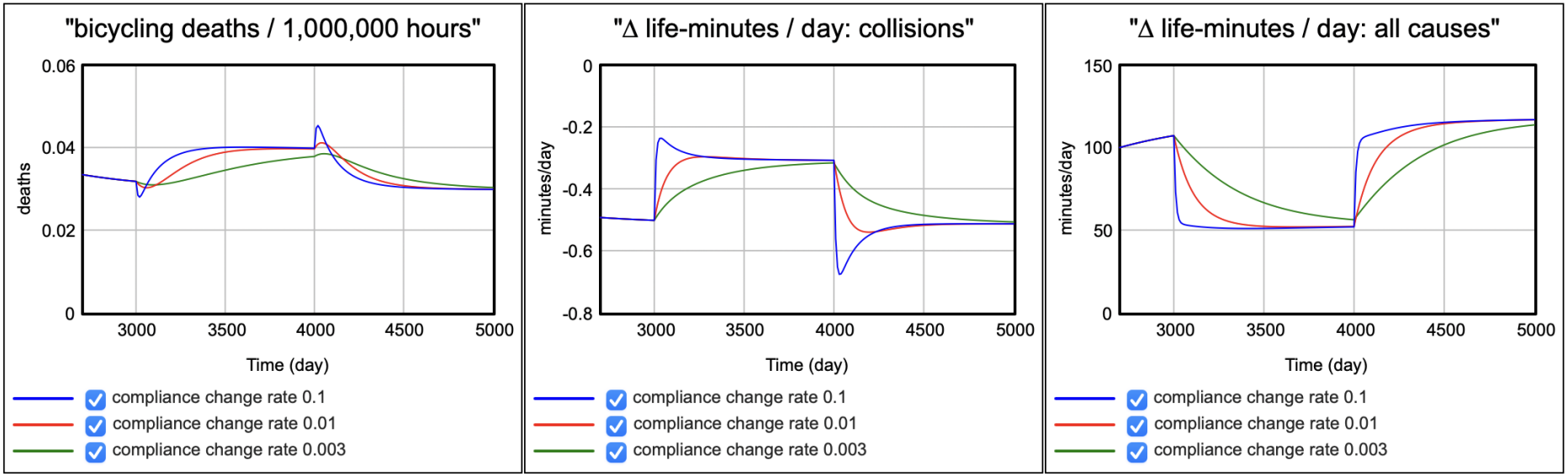
Introducing a helmet law



Bistability



Repeal: dangerous, but only for politicians?



Summary

Helmet laws—assuming perfect helmets:

- Increases safety by constant factor $\lesssim 25\%$
- Extend life expectancy by $\sim$ **1–2 weeks.**
  - Only affects current cyclists
- Suppress feedback loops that encourage cycling.

Encouraging cycling:

- Activates virtuous safety–convenience feedback loops
- Increases safety polynomially $\rightarrow$ factors $> 10\times$?
- Decreases burden of diseases of inactivity.
  - Positive effects for non- and not-yet-cyclists
  - Extends (healthy!) life expectancy by $\sim$ **2–4 years.**
- All those other benefits. . .

Take-home

Helmet laws:

May yield small short-term gains while inhibiting large long-term gains from reinforcing feedbacks.

Cost:benefit ratio can easily exceed 100:1

$\rightarrow$ *Treat helmet policies with extreme caution!*

Future work

- Social signals $\overset{?}{\approx}$ laws
- What controls β?
  - Data $\leftrightarrows$ dynamic modelling
- Dynamics of other Mechanisms
- Traffic models, learning agents
- 🚲 $\leftrightarrows$ 🚶 $\leftrightarrows$ 🛴 $\leftrightarrows$ 🛵 . . . ?
- Feedback? Collaborations?
  - Postdoc positions, etc. . . ?