

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

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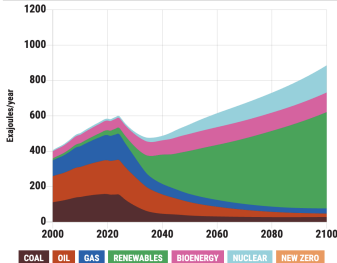
C-MUS
2024-09-23

EN-ROADS

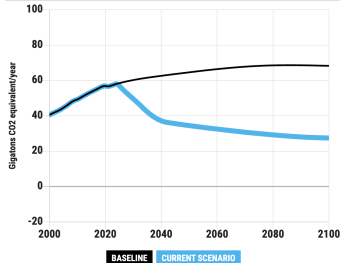
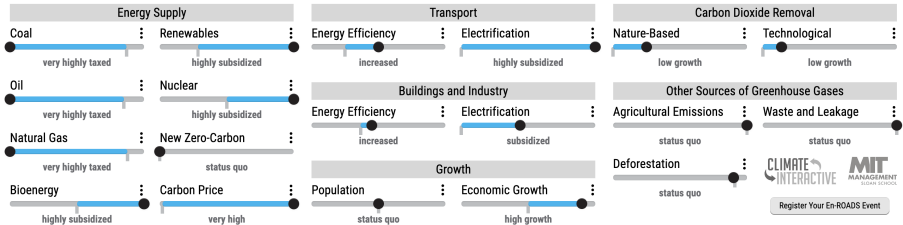
English ▾ Simulation ▾ Graphs ▾ View ▾ Help ▾ ↺ ↻ ↶ ↷ ↸ ↹

Share Your Scenario

Global Sources of Primary Energy



Greenhouse Gas Net Emissions

 $+2.3^{\circ}\text{C}$ $+4.1^{\circ}\text{F}$ Temperature
Increase by
2100CLIMATE
INTERACTIVE
MIT
MANAGEMENT
SCHOOL

Register Your En-ROADS Event

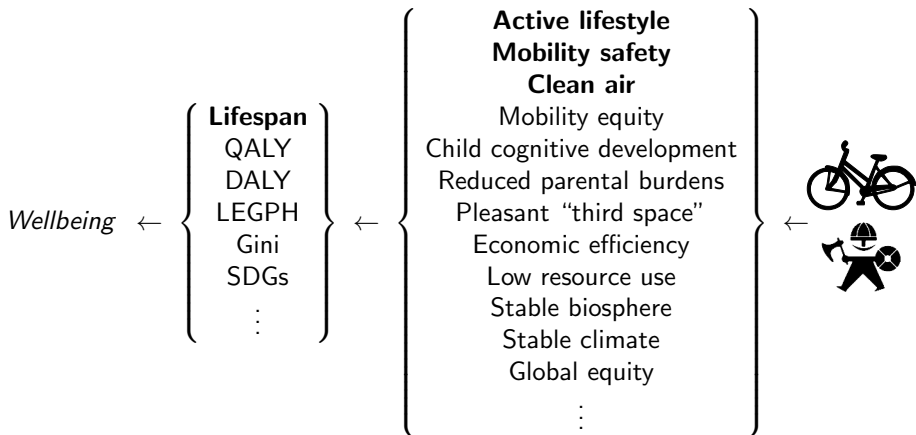
Transportation policy → *intrinsic good*

Objective

Correlate

Mechanisms

Technology



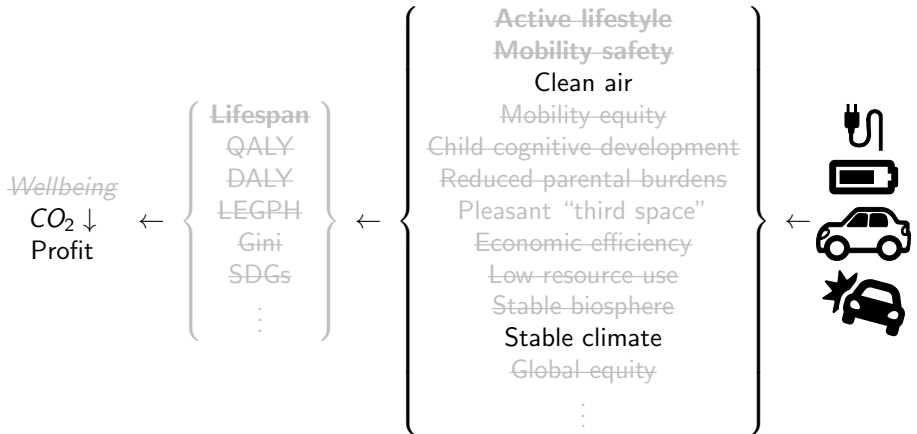
Transportation policy → *decarbonisation*

Objective

Correlate

Benefits

Technology



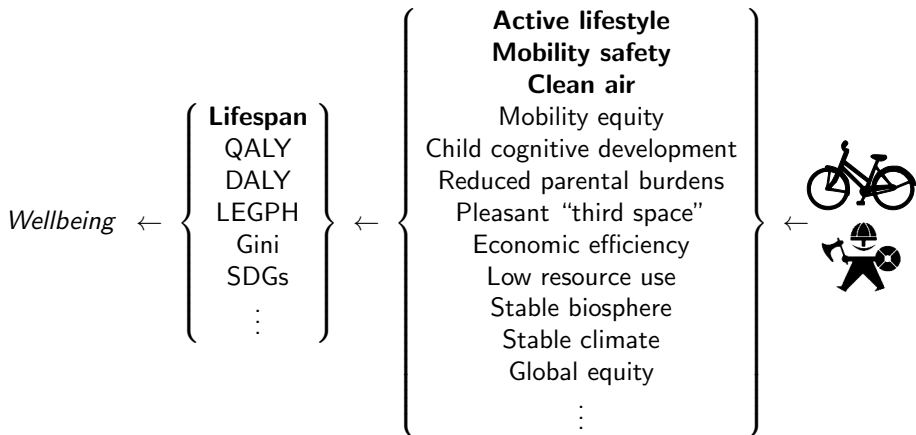
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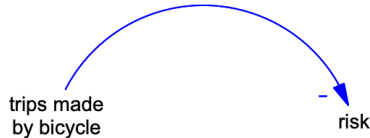
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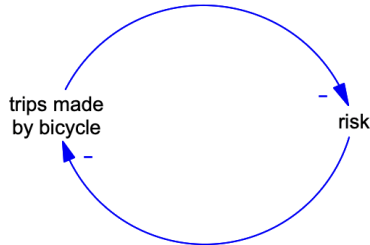
Biking \Leftrightarrow Safety-in-numbers

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



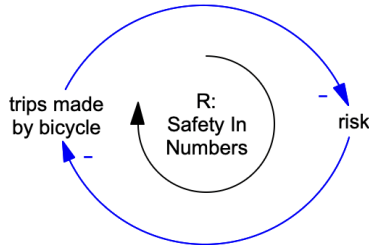
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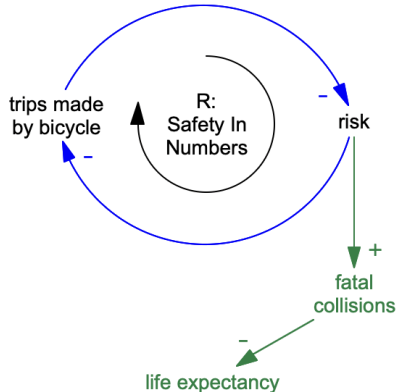
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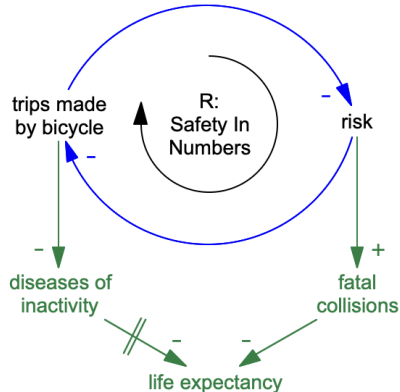
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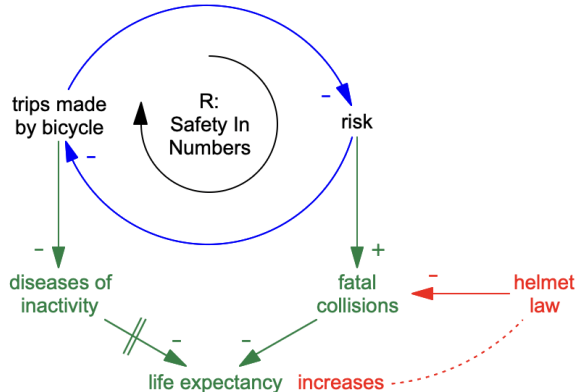
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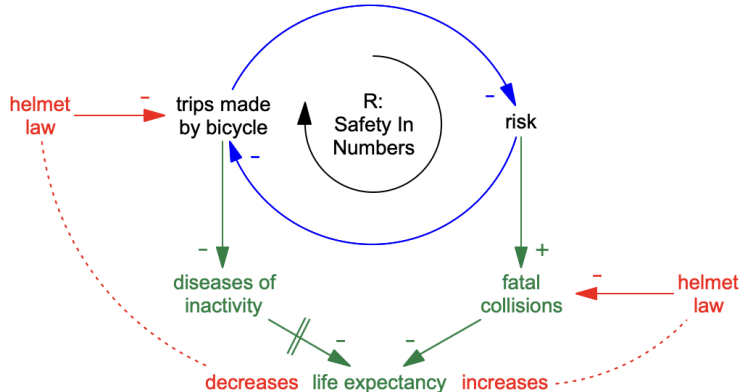
Helmet laws

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



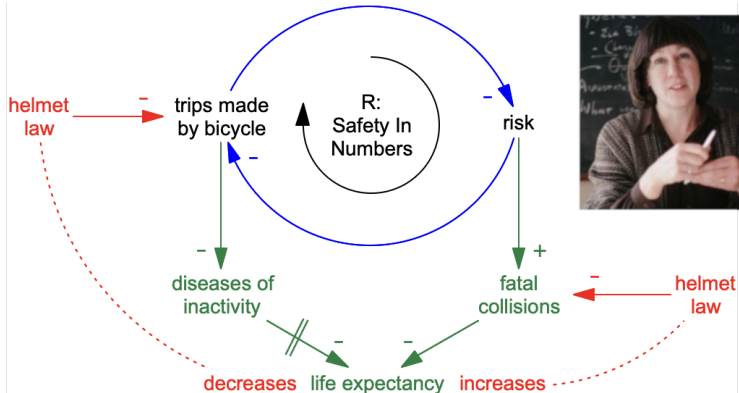
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The model

Life expectancy:

- Helmet requirements → Greater crash survivability
- Helmet requirements → Less biking
- More biking → Greater lifespan, healthspan, etc. . .

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Safety-In-Numbers feedback loop:

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Convenience infrastructure feedback loop:

- More biking \Leftrightarrow More bike-friendly infrastructure

The model

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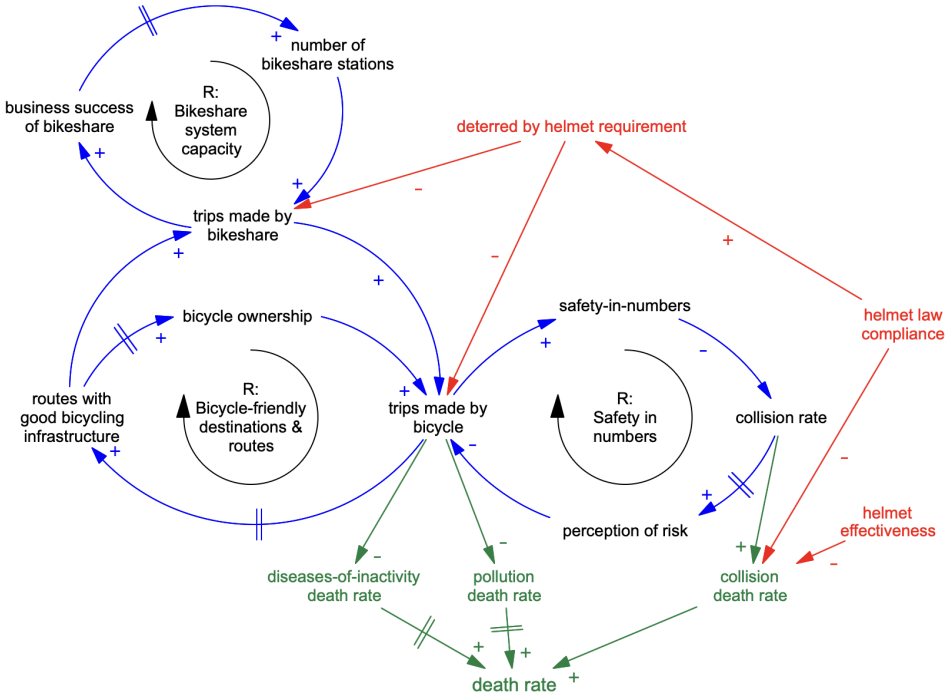
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Convenience infrastructure feedback loop:

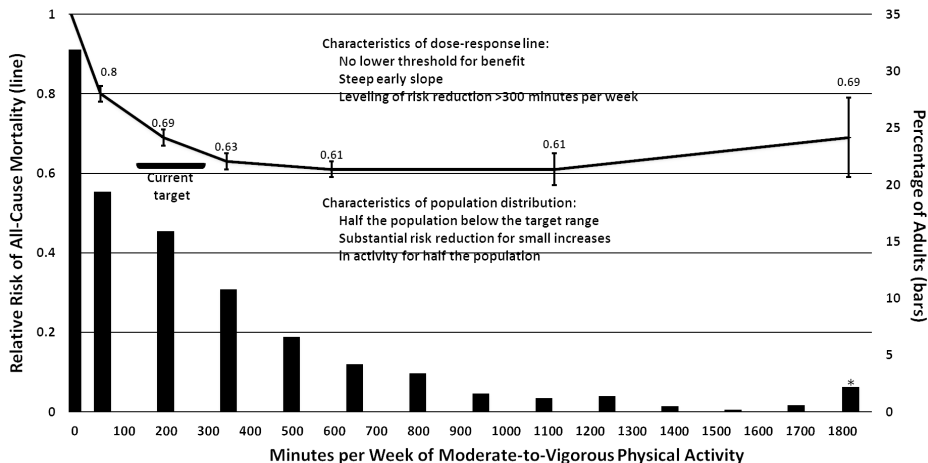
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Bikeshare business model feedback loop:

- More biking \Leftrightarrow More bikeshare stations
- Helmet requirements \rightarrow much less bikesharing



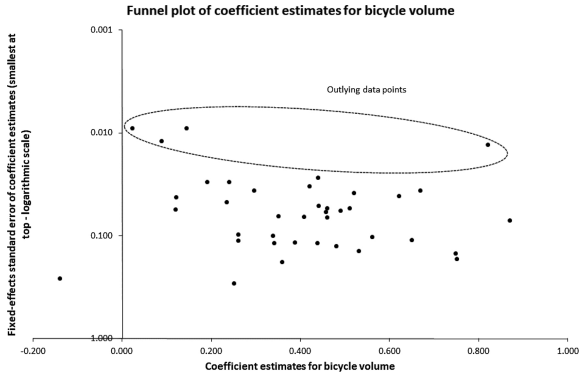
More biking → Greater lifespan, healthspan



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

More biking → Safer biking

- More biking $\times \rightleftharpoons$ safer biking: collisions $\propto (\Delta x)^\beta$
 - $\beta \approx [0.25 \dots 0.4]$
 - 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:

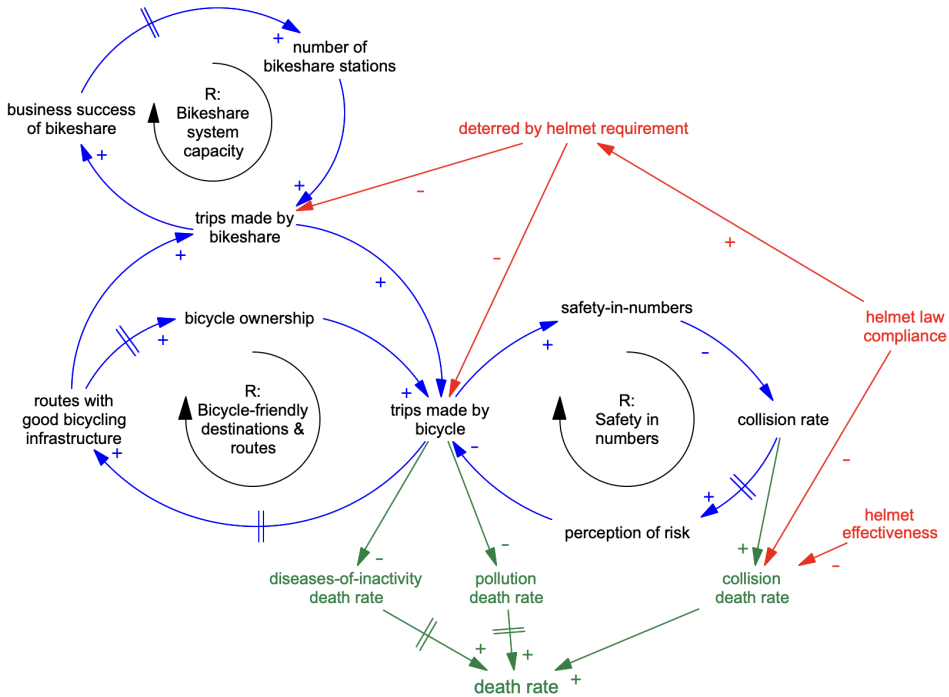
Frequent users: ?

Spontaneous trips: 80%?

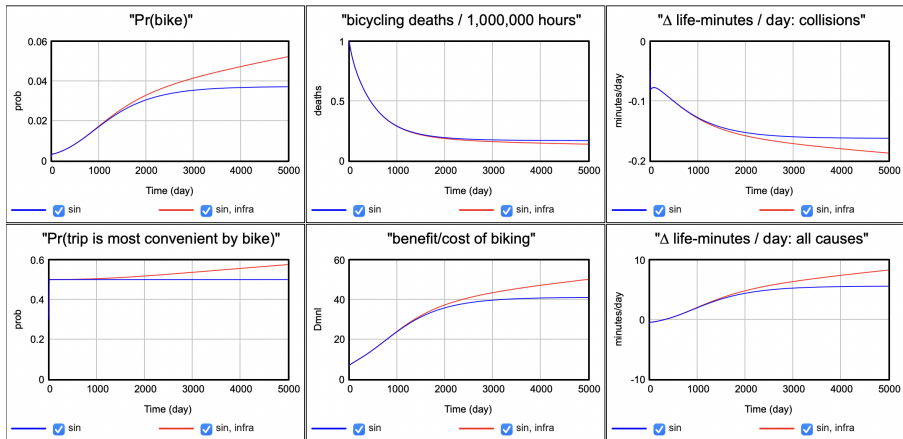
New user recruitment: 90%???

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

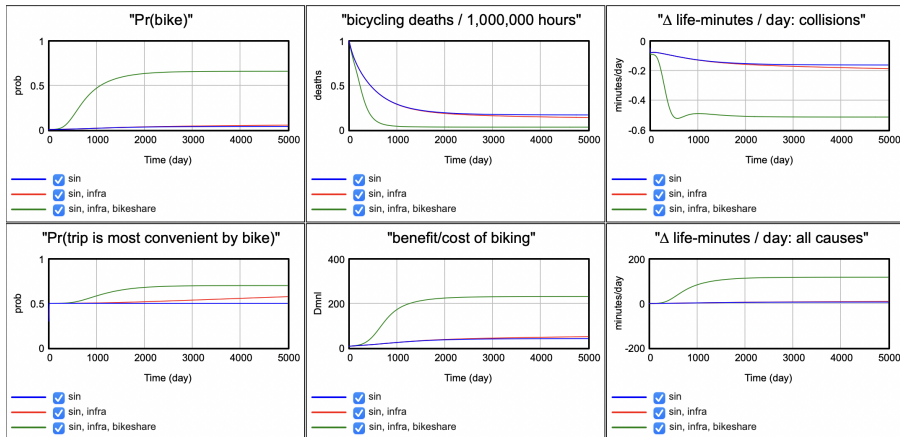
Biggest quantitative gap! But qualitatively OK.



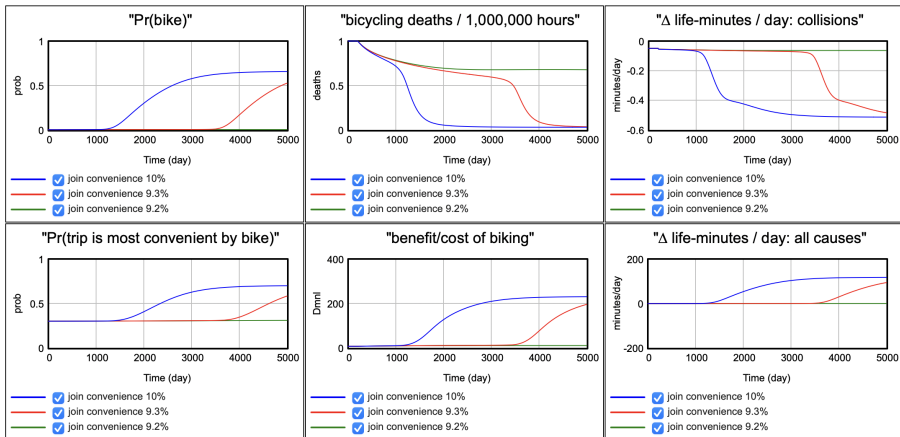
SIN, infrastructure, bikesharing



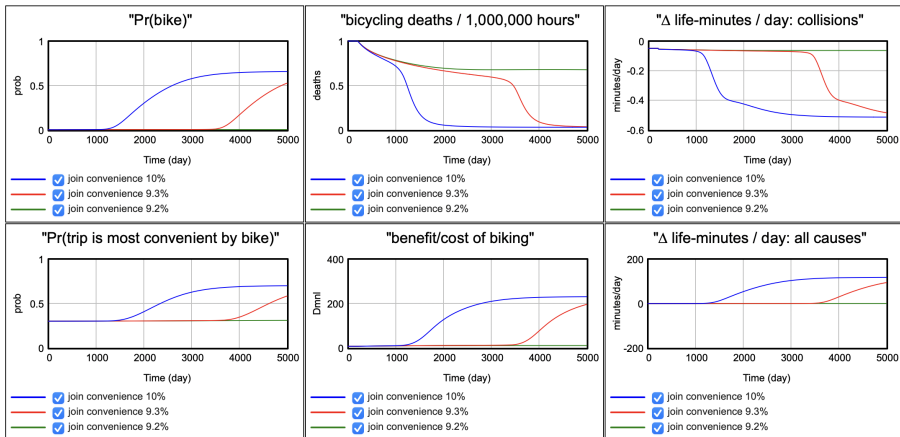
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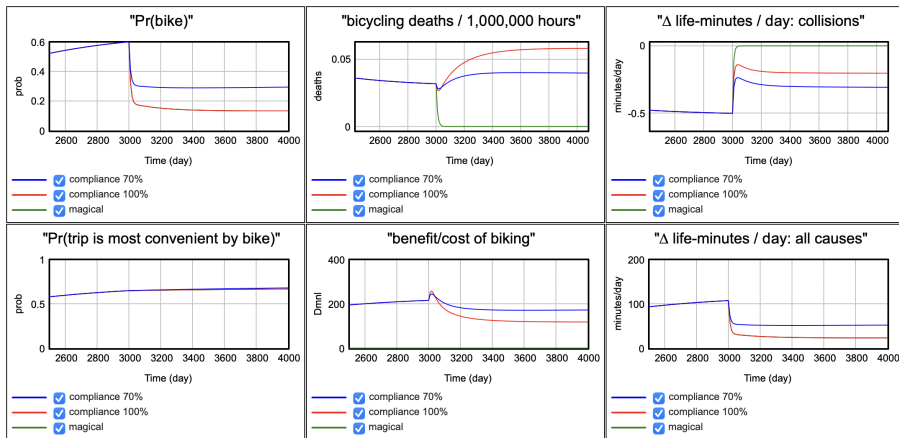
Introducing a bikeshare



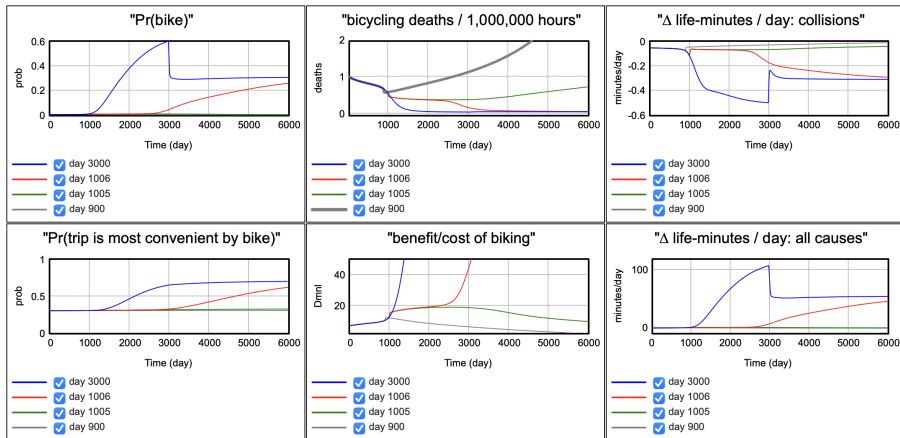
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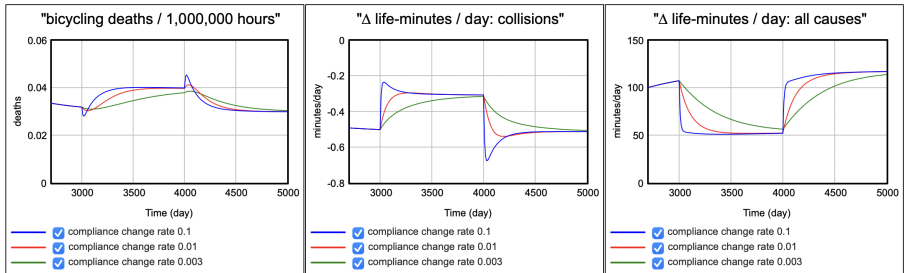
Introducing a helmet law



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**.
 - Affects $<$ current cyclists
- Suppress feedback loops that encourage cycling.

Encouraging cycling:

- Activates virtuous safety–convenience feedback loops
- Increases safety exponentially \rightarrow factors $> 10\times?$
- Decreases burden of diseases of inactivity.
 - Affects 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

→ *Treat helmet policies with extreme caution!*

Future work

- Social signals \approx laws?
- What controls β ?
 - Data \Leftrightarrow dynamic modelling
- Dynamics of other Mechanisms
- Traffic models, learning agents
-  \Leftrightarrow  \Leftrightarrow  \Leftrightarrow  ...?
- Feedback? Collaborations?
 - Postdoc positions, etc...?

