On the Path to Causal Inference

Mark Farragher

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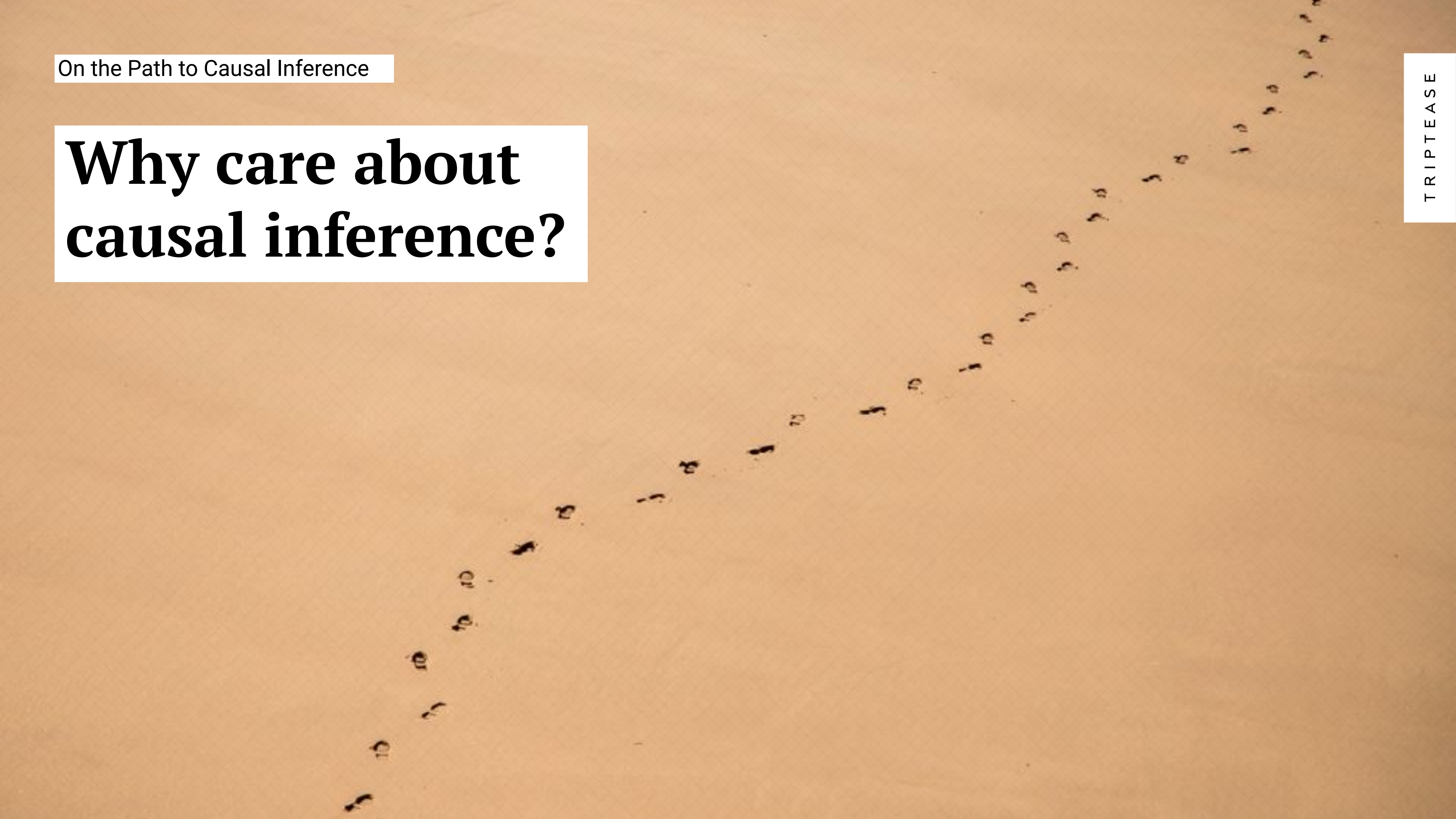
Agenda

- ➔ Why care about causal inference?
- ➔ The Ladder of Causation
- ➔ The causal diagram
- ➔ Types of biases that affect causal models

About me

- ➔ Background in quant economics
- ➔ …then moved into data science
- ➔ T R I P T E A S E (travel tech)
- ➔ Project: `appelpy`

Why care about causal inference?



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Causal questions are ubiquitous

- Social sciences
- Epidemiology
- Executives want ‘actionable insights’

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How does passive smoking affect the mortality of non-smokers?

What is the effect of minimum wage laws on employment?

What are the causes of customer churn at a software company?

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Ladder of causation

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Ladder of causation

- Counterfactual ('what if' I'd done X1 instead of X2?)
- Intervention (what happens to Y when I do X1?)
- Association (how do X1 and Y relate?)

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In the news today!

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JAMA Network Open

JAMA Network Open Enter Search Term

Original Investigation | Pediatrics

July 12, 2019

Association of Preterm Birth and Low Birth Weight With Romantic Partnership, Sexual Intercourse, and Parenthood in Adulthood

A Systematic Review and Meta-analysis

Marina Mendonça, PhD[1]; Ayten Bilgin, PhD[1,2]; Dieter Wolke, PhD[1,3]

» Author Affiliations | Article Information

JAMA Netw Open. 2019;2(7):e196961. doi:10.1001/jamanetworkopen.2019.6961

- → Paper talks about ‘association’
- → Press release uses language of causation (subconsciously?)

Causal diagram

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A night in the Tower?

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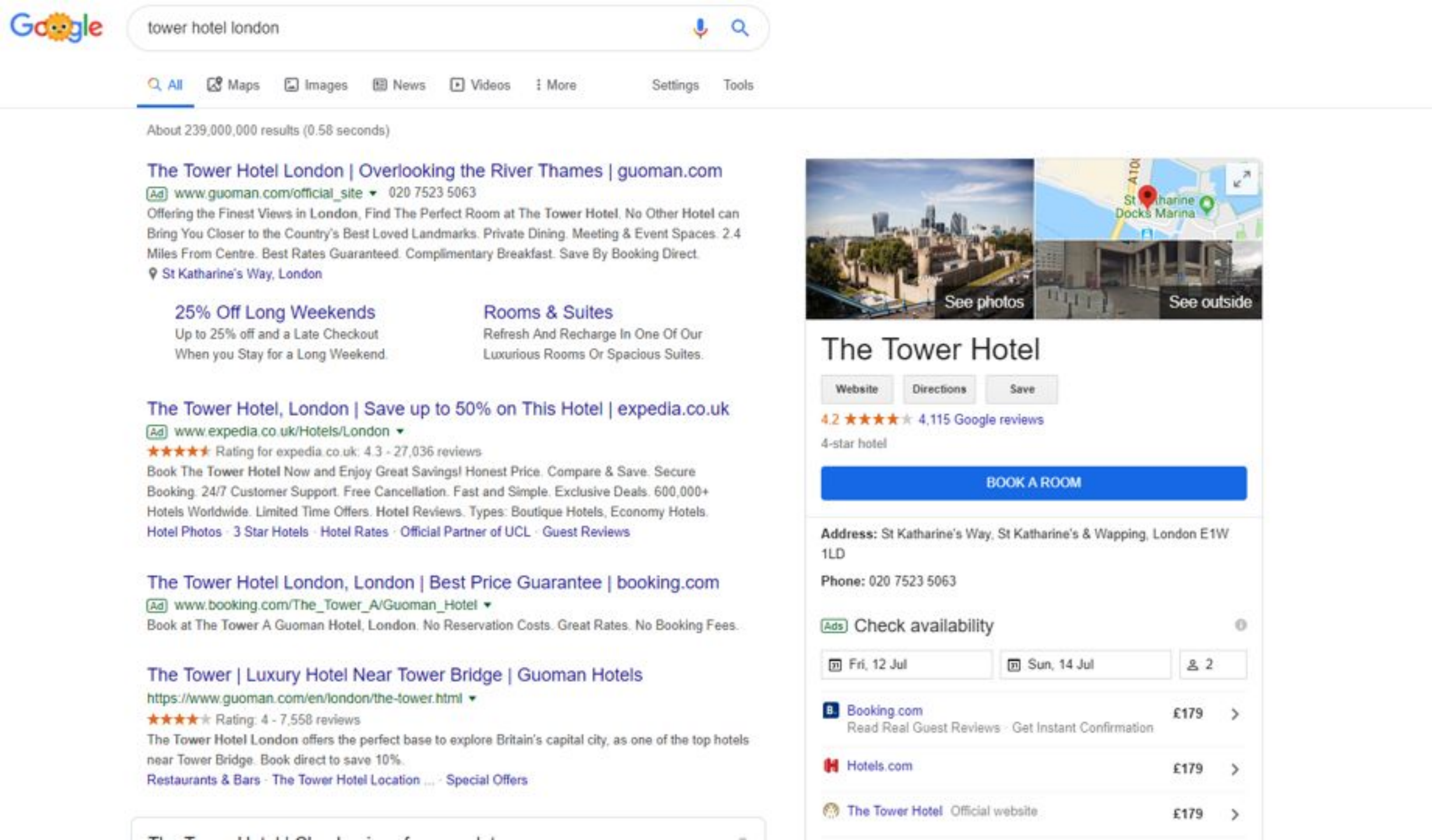
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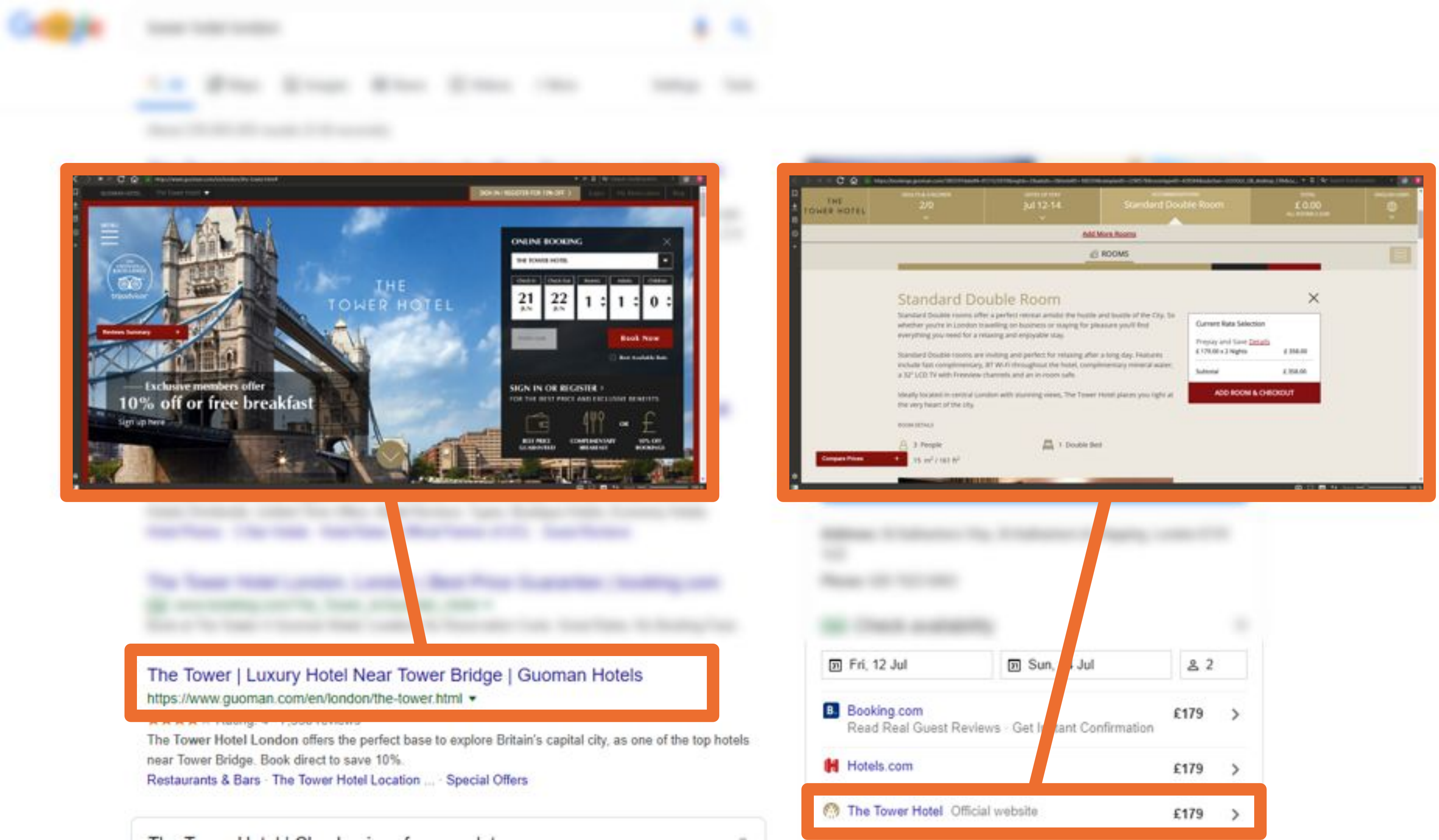

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Hotel website funnel (example)

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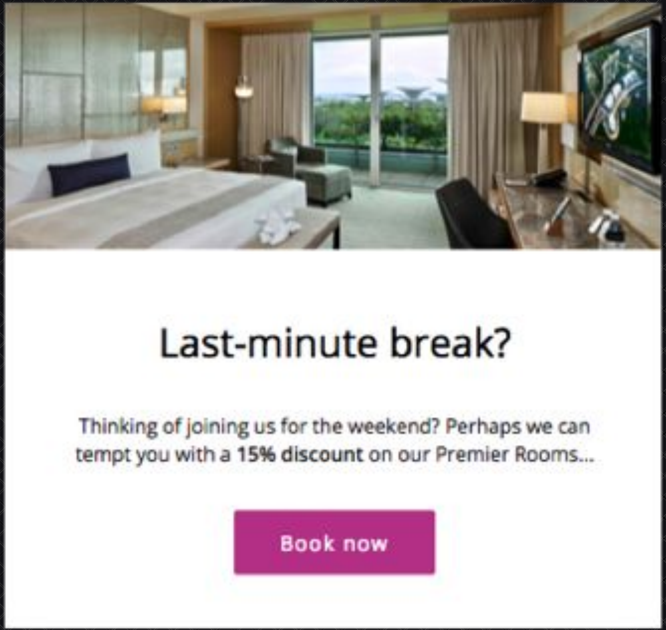
What could affect conversion rate?

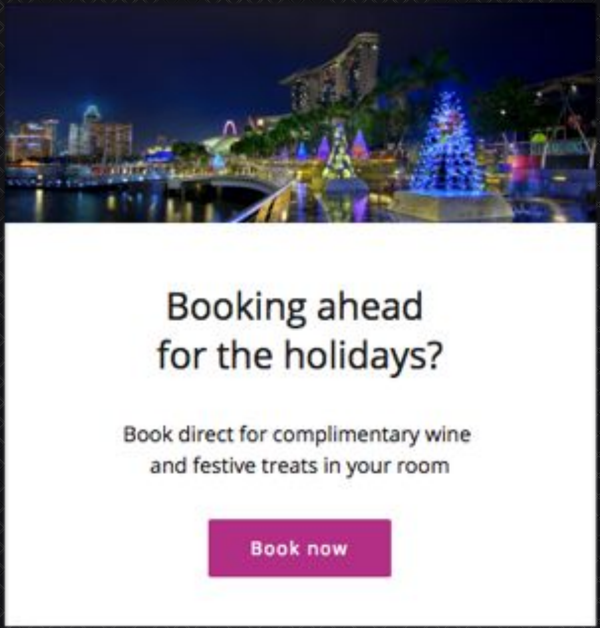
- ➔ Seasonality (hour of day, day of week, week of year)
- ➔ Traffic source (organic, paid, etc.)
- ➔ Device
- ➔ Price factors
- ➔ …and much more!

Consider two theories

- **Personalised messages** on hotel websites have a positive effect on conversion rate.
- **Searchers from Google** have a higher likelihood of booking a hotel room.

Messages


Last-minute break?
Thinking of joining us for the weekend? Perhaps we can tempt you with a **15% discount** on our Premier Rooms...
Book now


Booking ahead for the holidays?
Book direct for complimentary wine and festive treats in your room
Book now

Experimentation

- ➔ Can the treatment be randomly assigned?
- ➔ **Personalised messages**: YES (but the scale of data can be an issue).
- ➔ **Searchers from Google**: NO.

Diagram: effect of *messages*

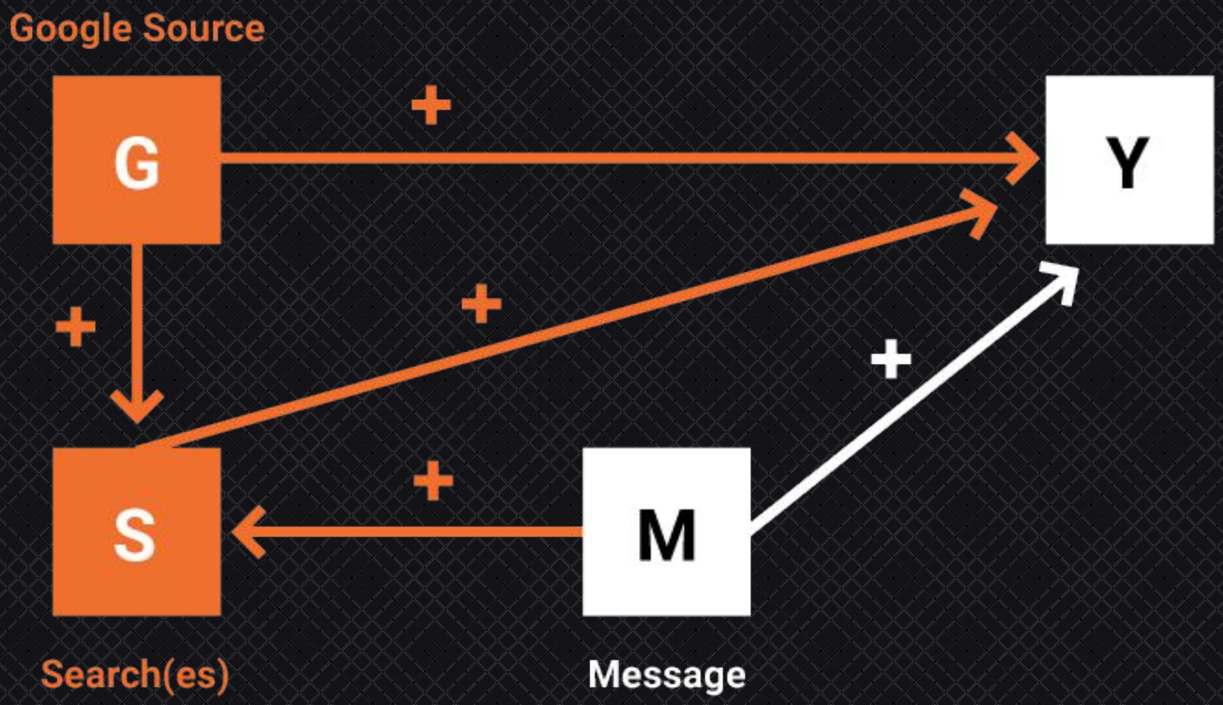


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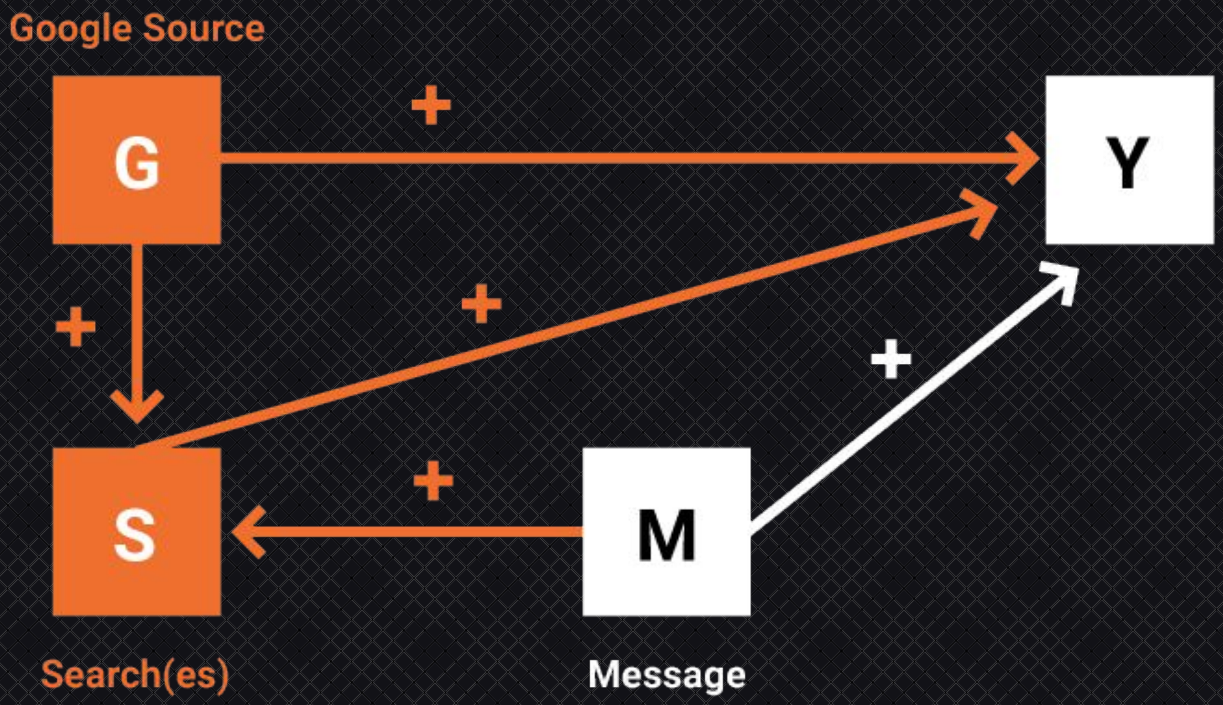
Diagram: effect of *messages*



M → S → Y

No collider

Block with {S}

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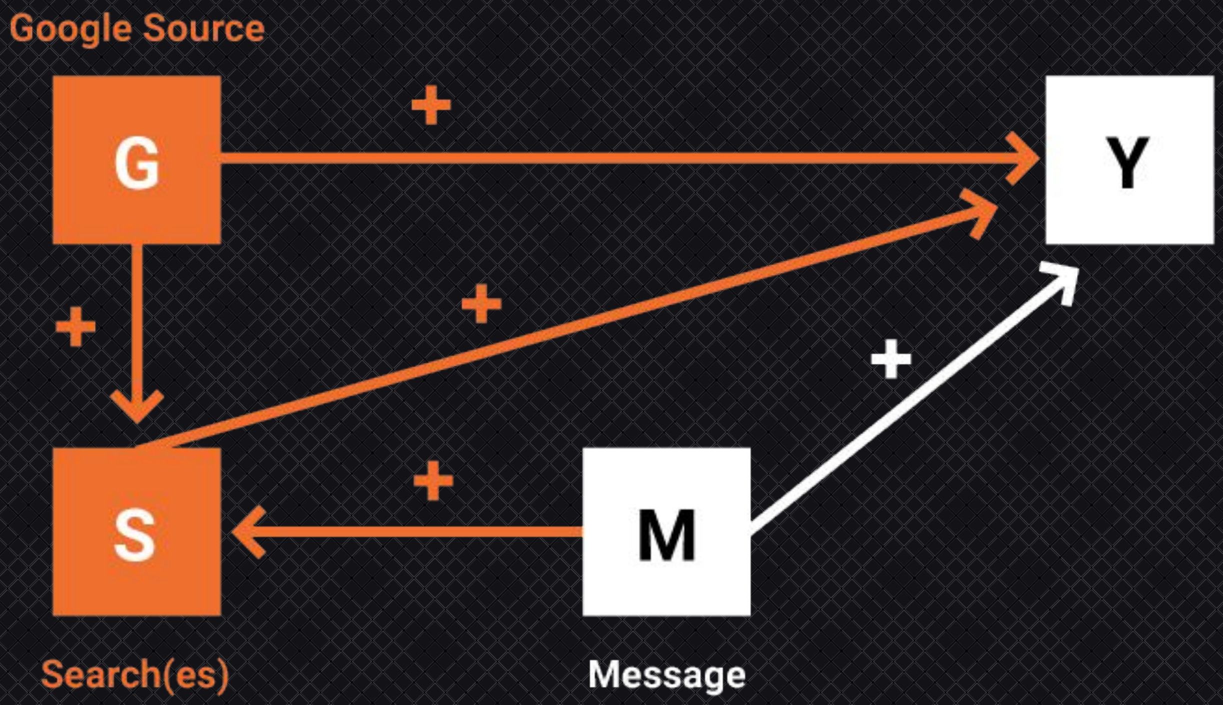
Diagram: effect of *messages*



$M \longrightarrow S \longleftarrow G \longrightarrow Y$

S is collider here!

$M \longrightarrow |S| \longleftarrow G \longrightarrow Y$

Block with {G}

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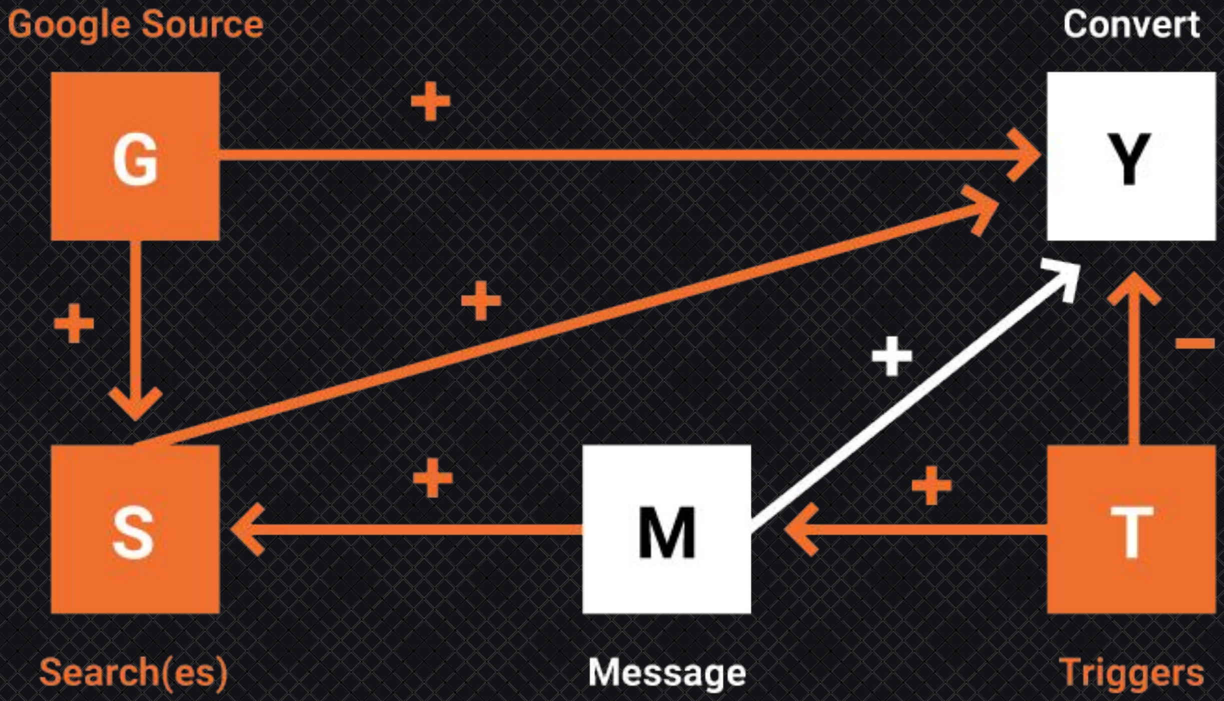
Diagram: enter message triggers



$M \leftarrow T \rightarrow Y$

No collider

Block with {T}

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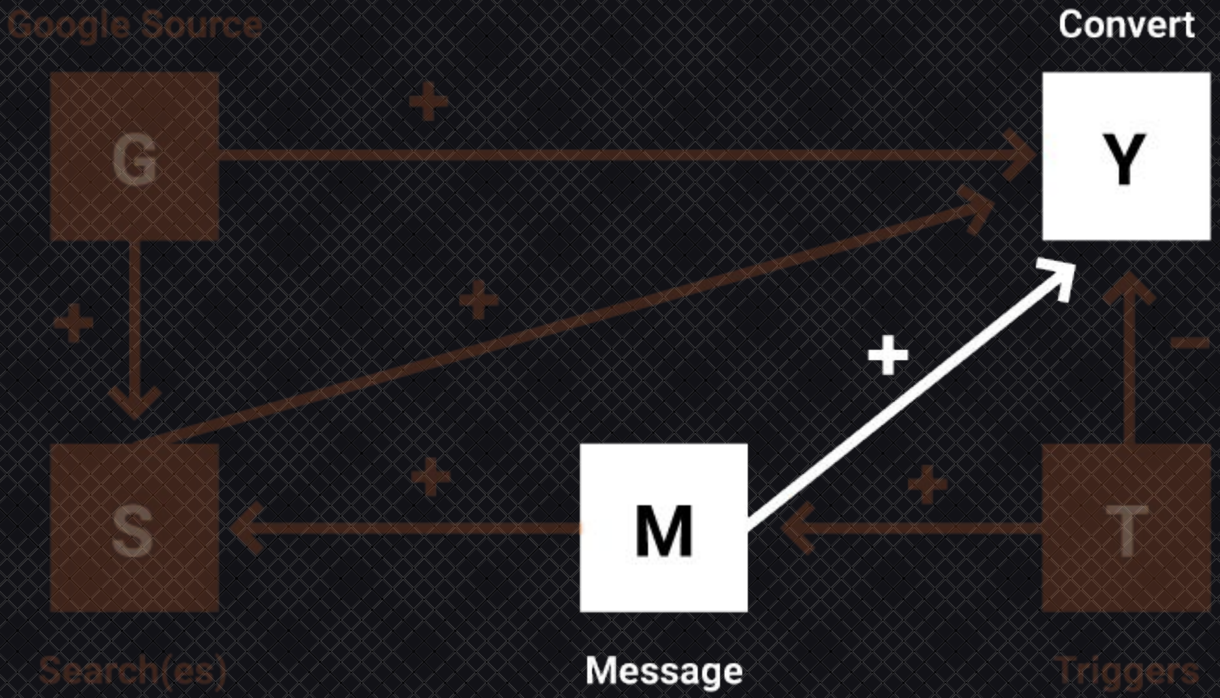
Diagram: A/B test



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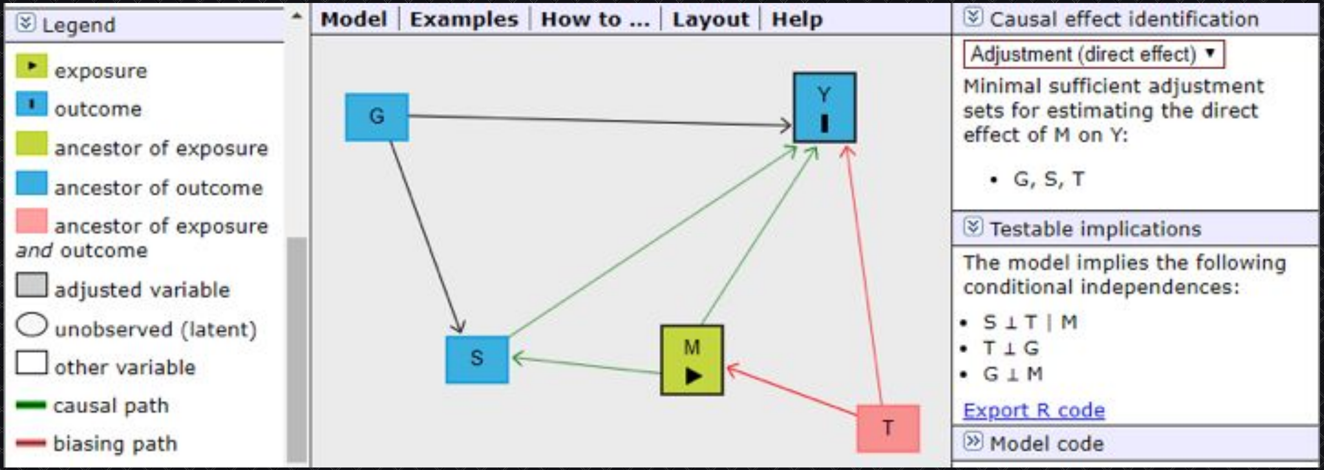
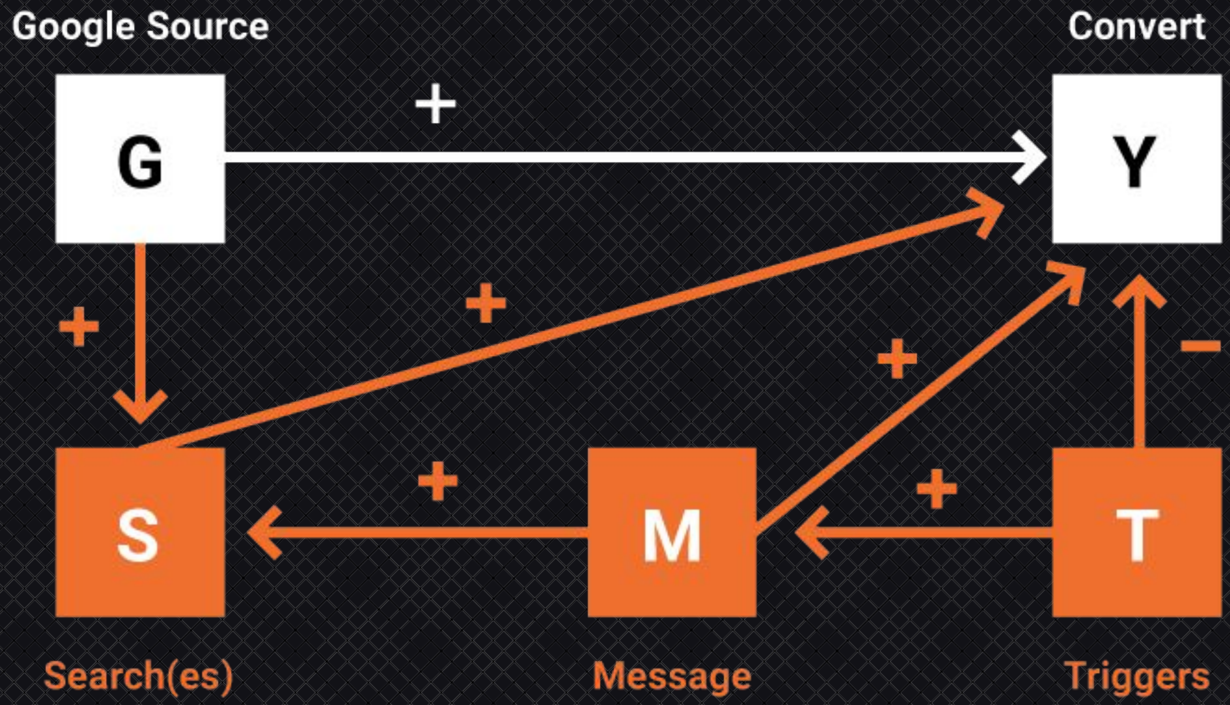
Tooling



- → Dagitty (above)
- → Python packages, e.g.: `causality; causalgraphicalmodels; dowhy`

Diagram: effect of *Google source*



Confounders: M & S

Control for {M, S}

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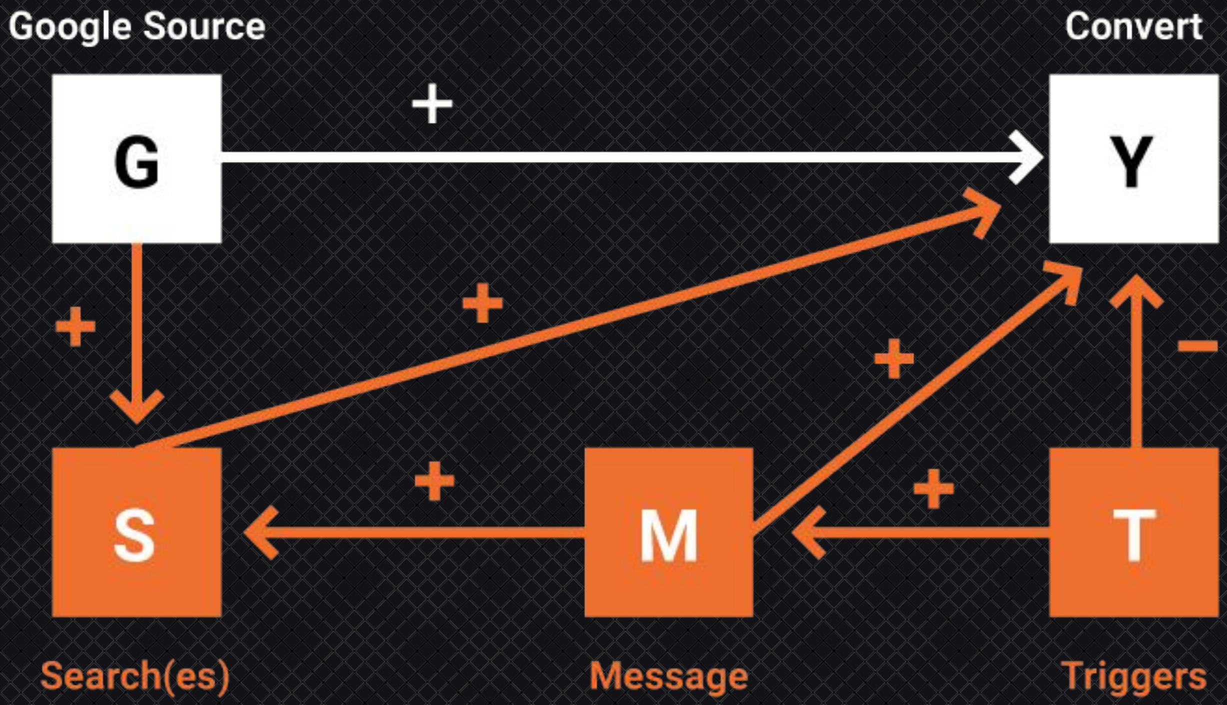
Diagram: effect of *Google source*



$G \rightarrow S \leftarrow M \leftarrow T \rightarrow Y$

S is collider here!

$G \rightarrow |S| \leftarrow M \leftarrow T \rightarrow Y$

Block with {M}

Why causal diagrams are great

- Assumptions for a model are explicit
- A toolkit for identifying appropriate control variables
- Diagrams can be refined iteratively

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Types of bias

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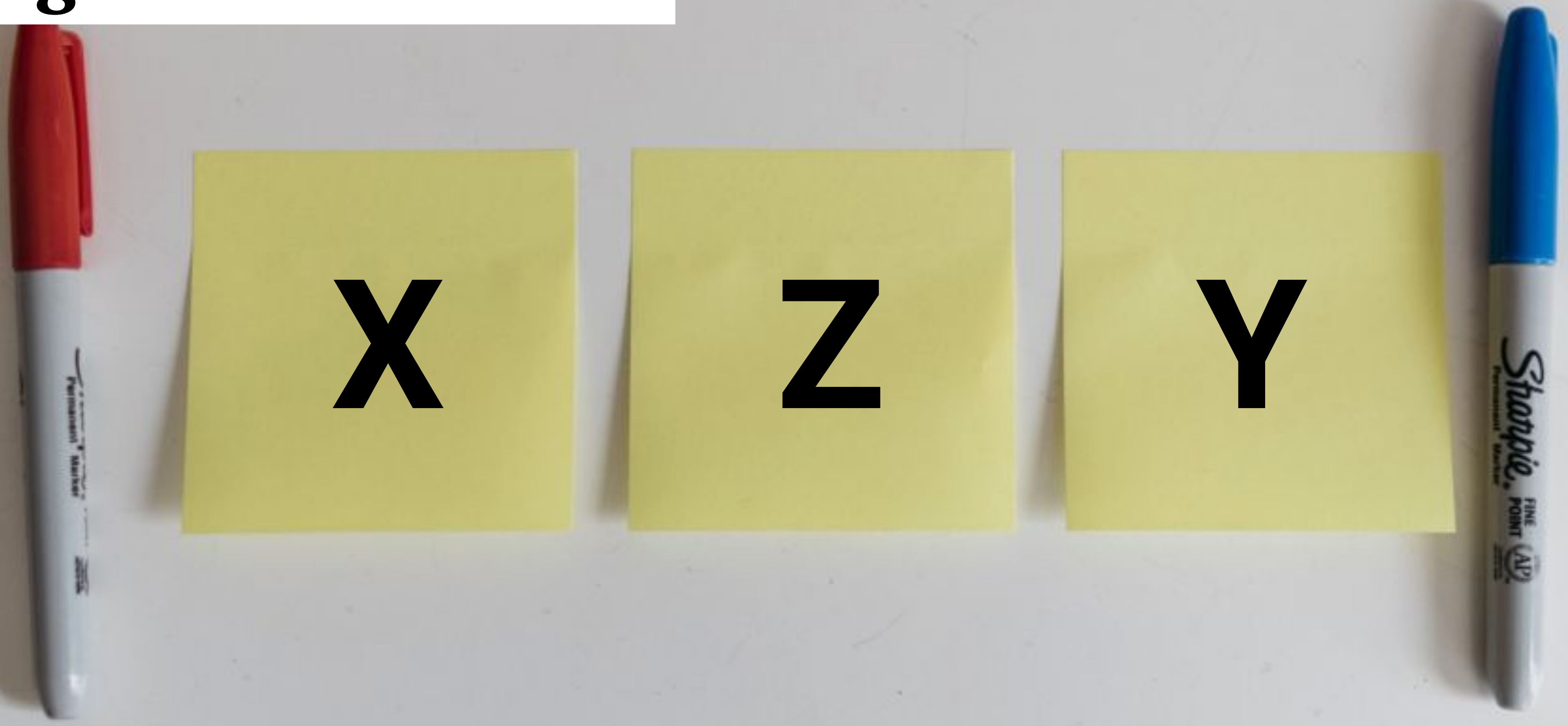
Regress Y on X & Z



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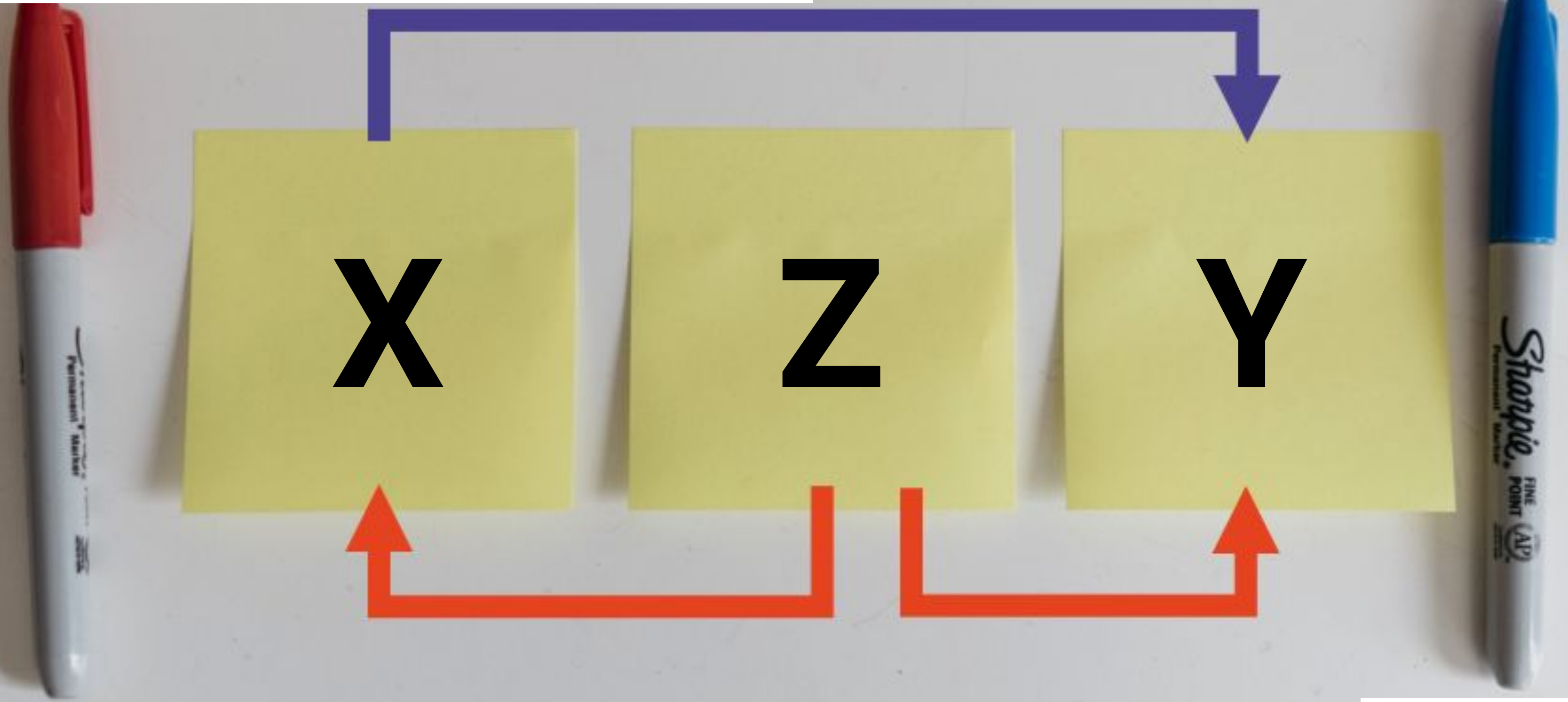
Z: confounding variable



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$X \leftarrow Z \rightarrow Y$

Confounders

- Control for confounders – they help your model’s estimates by:
  - Increasing their precision;
  - Reducing their bias.

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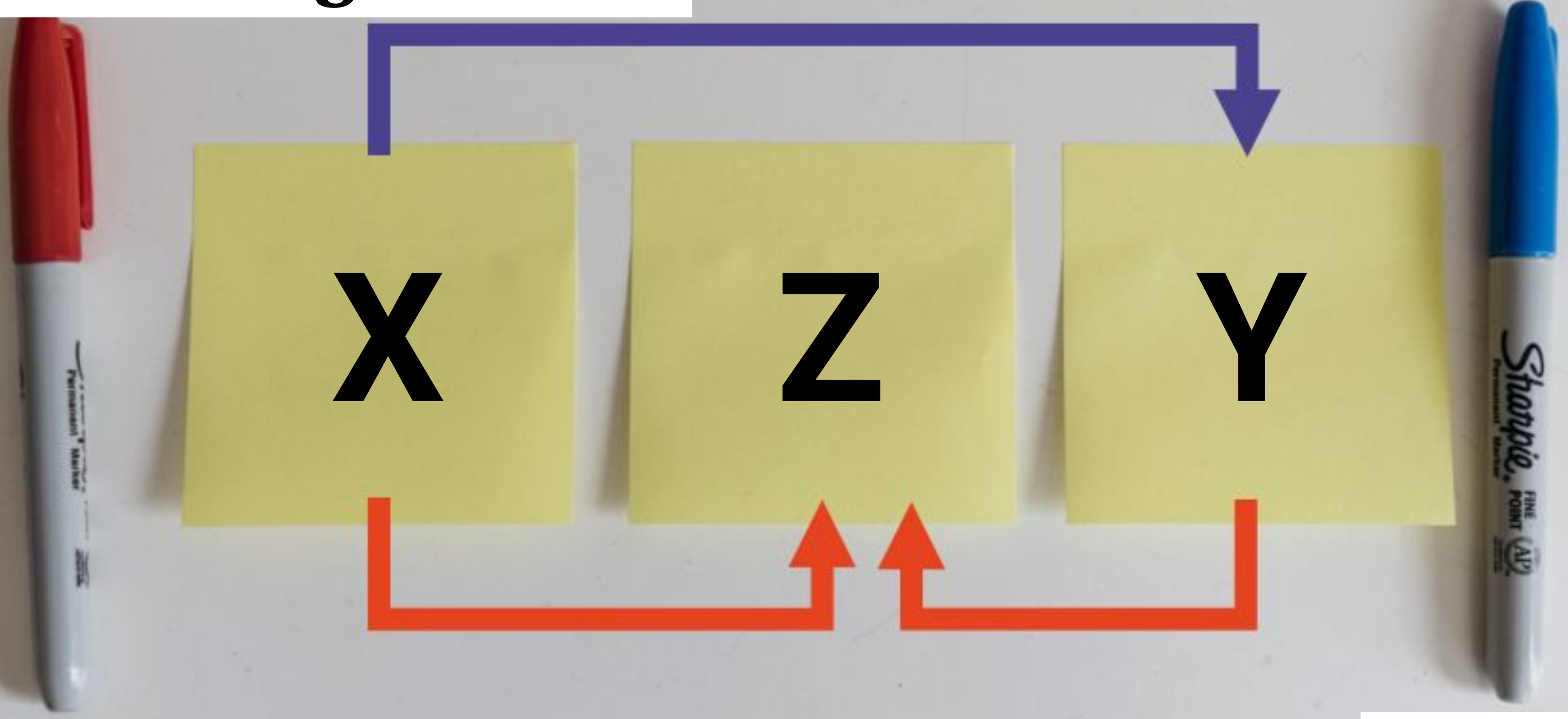
Z: colliding variable



$X \rightarrow Z \leftarrow Y$

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Colliders

- Collider automatically blocks backdoor path
- Common effect of X & Y – beware
- Sometimes a variable can be a collider & a confounder on different paths!

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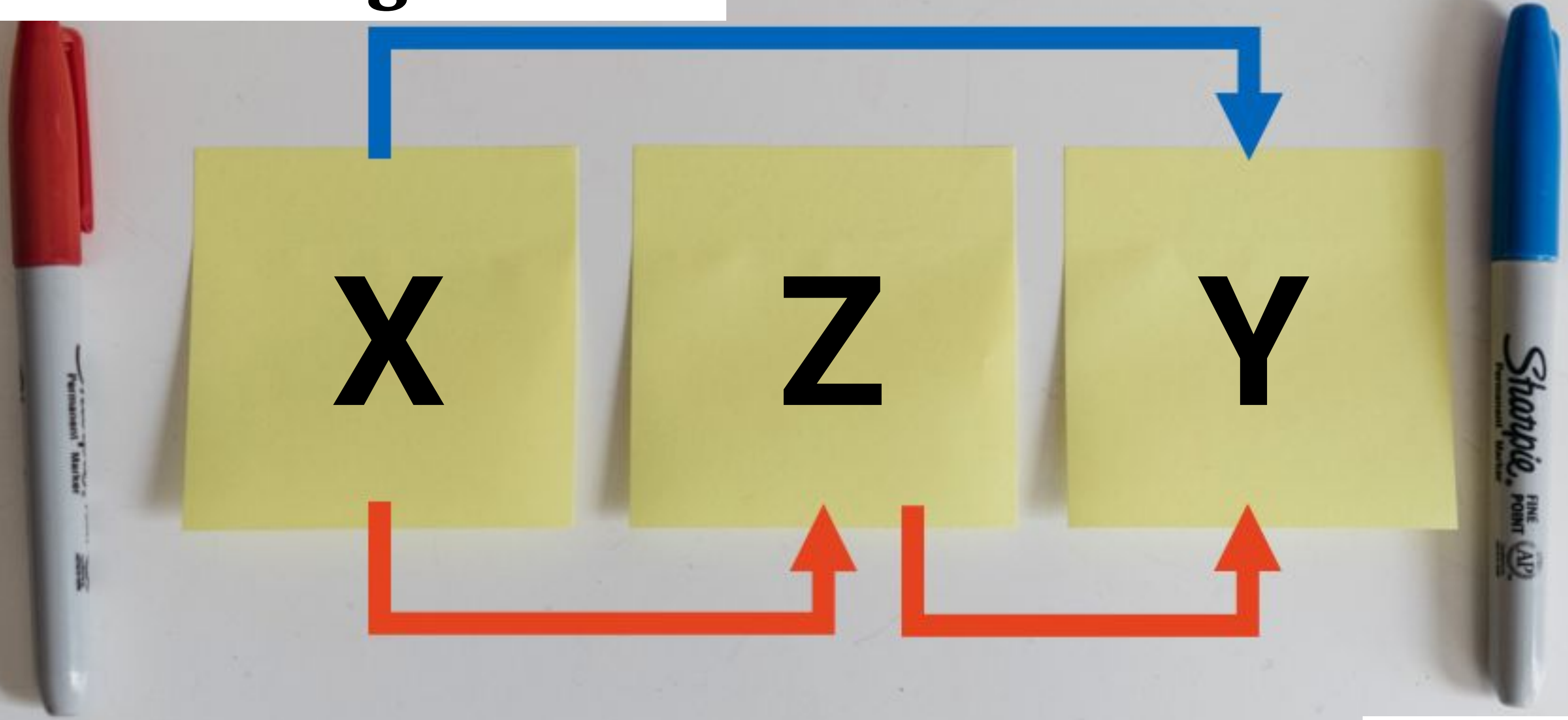
Z: mediating variable



$X \rightarrow Z \rightarrow Y$

Mediators

- A mediator (M) introduces an indirect effect of X on Y.
- If we care only about the total effect of X on Y, then there's no need to control for M.

Summary

- Causal questions are ubiquitous
- Causal effects can be estimated without randomised experiments (fortunately)
- The causal diagram is useful for modelling
- Control for confounders & beware of colliders
- Tools can assist with the choice of controls

Further resources

- Pearl: The Book of Why
- Angrist & Pischke: Mastering ‘Metrics
- Python libraries: `statsmodels`; `linearmodels`; `appelpy`

mfarragher

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