Geographic Data Science - Lecture IX

Causal Inference

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Today

- Correlation Vs Causation
- Causal inference
- Why/when causality matters
- Hurdles to causal inference & strategies to overcome them

Correlation Vs Causation

"Association breeds similarity" (sometimes)

Nasir bin Olu Dara Jones (a.k.a. *Nas*)

Correlation Vs Causation

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Two variables have **co-movement**. If we know the value of one, we know something about the value of the other one.

`Causation`

There is a **"cause-effect"** link between the two and, as a result, they display co-movement.

Correlation Vs Causation

- Both are useful, but for different purposes
- Causation *implies* correlation but **not** the other way around
- It is vital to keep this distinction in mind for meaningful and credible analysis

Examples

Sign correlation? Causal link?

Take a guess (2mins)...

- Temperature and ice-cream consumption
- Non-commercial space launches & Sociology PhDs awarded
- Crime & policing
- IMD Moran Plot in Liverpool

Examples

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- Temperature and ice-cream consumption → **Positive**. **Positive**.
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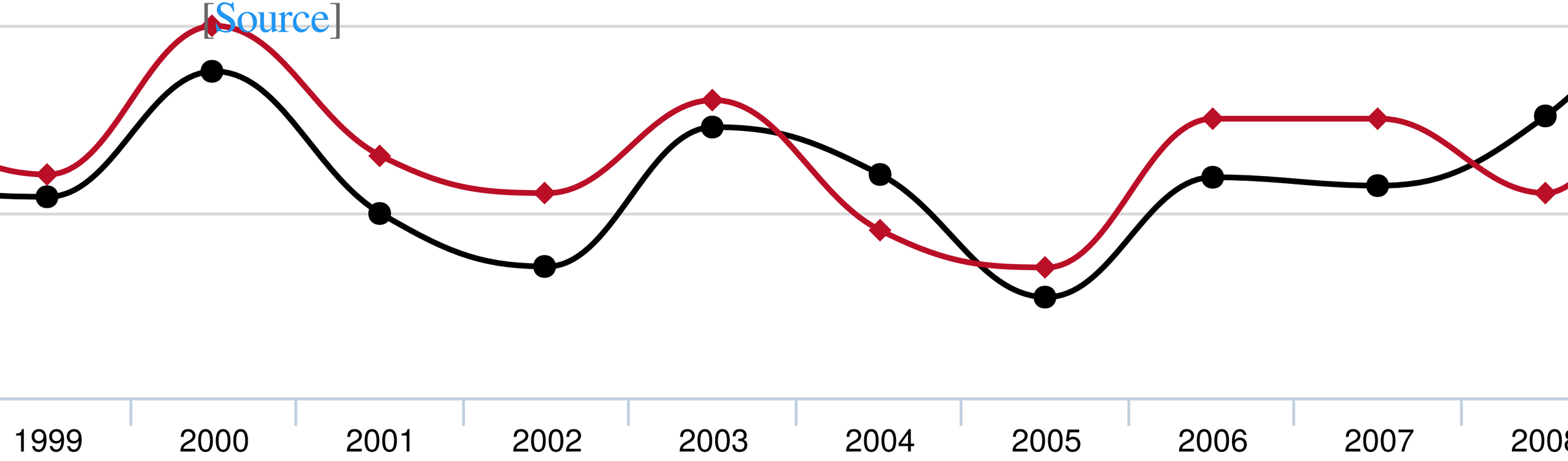
Worldwide non-commercial space launches

correlates with

Sociology doctorates awarded (US)

1999 2000 2001 2002 2003 2004 2005 2006 2007 2008

[Source]



Examples

Positive or negative correlation? Causal link?

Take a guess (2mins)...

- Temperature and ice-cream consumption → **Positive**. **Positive**.
- Non-commercial space launches & Sociology PhDs awarded → **Positive**. **None**.
- Crime & policing
- IMD Moran Plot in Liverpool

Examples

Positive or negative correlation? Causal link?

Take a guess (2mins)...

- Temperature and ice-cream consumption → **Positive**. **Positive**.
- Non-commercial space launches & Sociology PhDs awarded → **Positive**. **None**.
- Crime & policing → **Positive**. **Negative**.
- IMD Moran Plot in Liverpool


2
1
0
−1
−2

Examples

Positive or negative correlation? Causal link?

Take a guess (2mins)...

- Temperature and ice-cream consumption → **Positive**. **Positive**.
- Non-commercial space launches & Sociology PhDs awarded → **Positive**. **None**.
- Crime & policing → **Positive**. **Negative**.
- IMD Moran Plot in Liverpool → **Positive**. **?**

Causal inference

[Source]

Why/When get causal?

Why

- Most often, we are interested in understanding the **processes** that *generate* the world, not only in observing its outcomes
- Many of these processes are only **indirectly observable** through **outcomes**
- The only way to link both is through **causal channels**

When

Essentially when the **core interest** is to find out if **something *causes* something else**

- Policy interventions
- Medical trials
- Business decisions (product/feature development...)
- Empirical (Social) Sciences
- ...

When not (necessarily)

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Exploratory analysis

When you are not sure what you are after, inferring causality might be too high of a price to pay to get a sense of the main relationships

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Predictive settings

Interest not in understanding the underlying mechanisms but want to obtain **best possible estimates** of a variable you do not have by combining others you do have

E.g. Population density in a specific point using population density in all available nearby locations

Hurdles to causal inference

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Causation *does* ***not*** *imply* Correlation

Why?

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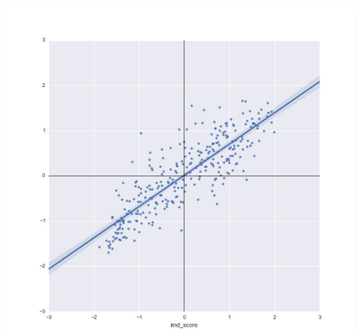

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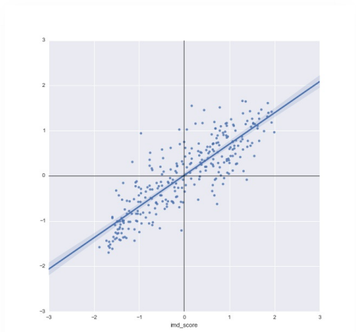

Why?

- Reverse causality
- Confounding factors/endogeneity

Reverse causality

There *is* a causal link between the two variables but it either runs the oposite direction as we think, or runs in both

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E.g. Education and income

Confounding factors

Two variables are correlated because they are *both* determined by other, unobserved, variables (factors) that *confound* the effect

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E.g. Ice cream and cold beverages consumption

Strategies

Is there any way to overcome reverse causality and confounding factors to recover causal effects?

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The key is to get an *exogenous source of variation*

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Randomized Control Trials

Treated and *control* groups

Probability of treatment is independent of everything else

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Like a RCT, but that just *"happen to occur naturally"* (natural dissasters, exogenous law changes...)

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Econometric techniques

For the interested reader: space-time regression, instrumental variables, propensity score matching, differences-in-differences, regression discontinuity...

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... correlation most often *precludes* causation and, depending on the application/analysis, it is all that is needed.

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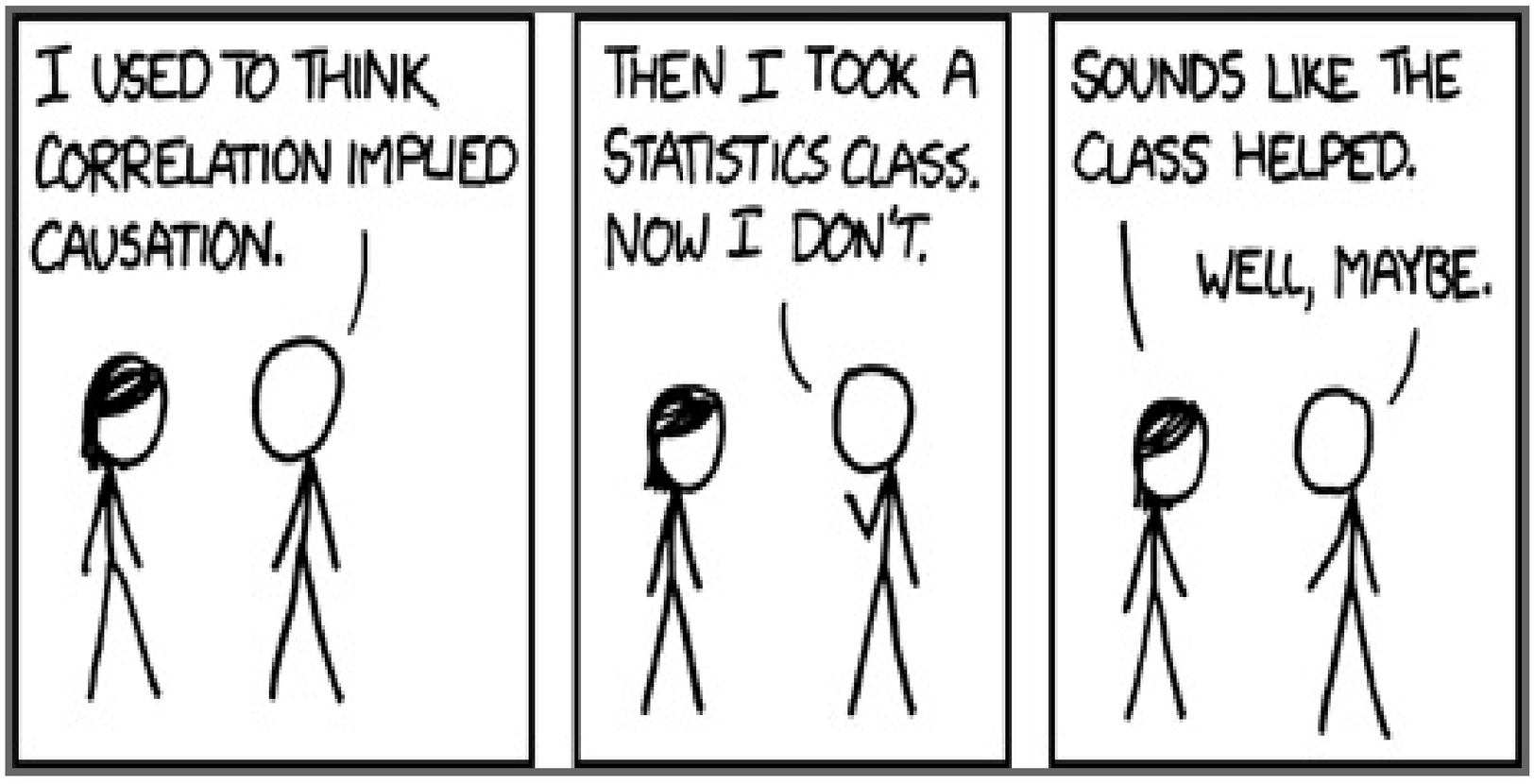
... correlation most often *precludes* causation and, depending on the application/analysis, it is all that is needed.

It is important to always draw **conclusions based on analysis**, know what the data can and cannot tell, and stay **honest**.

Recapitulation

- Correlation does **NOT** imply causation
- Causality implies more than correlation, a direct **effect channel** that is **harder** to identify but might be **worthwhile**
- There are several techniques to identify causality, all usually based on obtaining **exogenous sources of variation**
- You don't always need causality


I USED TO THINK CORRELATION IMPLIED CAUSATION.
THEN I TOOK A STATISTICS CLASS. NOW I DON'T.
SOUNDS LIKE THE CLASS HELPED.
WELL, MAYBE.

[Source]