

Elements of quantitative research

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Roadmap

Theories and research questions

Concepts and operationalization

Measurement

Describing variables and relationships

Prediction

Example: Wartime civilian deaths

Paper discussion

Research and RQs

- Research answering questions
- Re-cap on research types
 1. **Normative** vs. **positive** research
 2. Positive: **theoretical** vs. **empirical**
 3. Empirical: **Descriptive, explanatory**

Research and RQs

- Research answering questions
- Re-cap on research types
 1. **Normative** vs. **positive** research
 2. Positive: **theoretical** vs. **empirical**
 3. Empirical: **Descriptive, explanatory**
And **predictive?**

Example on types of questions and evidence

- Imagine you are doing the analytics previous to creating a campaign for Mahou
- Think of questions that are:
 - Quantitative and descriptive
 - Quantitative and explanatory
 - Qualitative and descriptive
 - Qualitative and explanatory



What is a research question?

- Any question we can answer
 - Sometimes we say that we derive an RQ from a topic, and a theory from an RQ
- **Topic > RQ > Theory**

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- In reality, an RQ can be thought of as an operationalization of an argument
 - **Previous evidence > Argument > RQ > Hypotheses**
- **Even though** this ‘argument’ can be something anecdotal that we later develop into a proper, abstract theoretical argument

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- **Even though** this ‘argument’ can be something anecdotal that we later develop into a proper, abstract theoretical argument
 - And it would actually look into something like this:
 - Previous > ‘Anecdotal argument’ > RQ > (Proper) Theory > Hs

Good RQs, in brief

1. Empirically **answerable**

→ i.e. you can answer it with data

2. Theoretically **relevant**

→ i.e. it helps you learn something about your theory/argument

Good RQs, more in detail

1. Consider potential results of the analyses
 - if you found X, does that answer the question?
 - example: are kids who play videogames often more aggressive?
 - does that inform a theory on the aggressiveness effect of VGs?
2. Is it feasible?
 - do you have the data? is it possible to do it? (e.g. re-offenders)
 - also: is there any design or strategy to answer it?
3. Keeping it simple and narrow
 - what are the causes of economic underdevelopment? vs. does exposure to natural disasters hinder economic development?

Example on generating RQs

- Couple things to remember:
 - RQs are often the link between theory and empirics
 - So they already suggest which variation to look at

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- Couple things to remember:
 - RQs are often the link between theory and empirics
 - So they already suggest which variation to look at
- Imagine you have the following argument:

How good students do at school depends more on the peers they are surrounded by than on the quality of the teaching they receive
- Which RQ could let us test this?

Stories, RQs, and theories

- There're no exclusive definitions of 'stories' and theories
- It's just about getting to a sufficient level of abstraction
- Often, you start with a story or example, and then you move up the ladder for both theory and RQs until you get to a general theory tested with a RQ

Generating theories

- No recipe for this, everyone generates theories *all the time*
- Usually it refers to an analytical argument that explains something
 - It could also be a descriptive or predictive theory, but even in those cases there's probably an explanation underneath
- Developed inductively, from descriptive data to general explanations
- My advice: if you can't tell a story out of the theory, you're not there yet (i.e. need to be able to travel from/to abstraction)

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- **Q:** How to identify a **good theory**?

Evaluating theories

1. Simple

Evaluating theories

1. Simple
2. Internally coherent and able to explain variation

Evaluating theories

1. Simple
2. Internally coherent and able to explain variation
3. Testable

Example (of the whole process)



Example

- That's some descriptive evidence that could inspire an anecdote
- The **anecdotal argument** (think of a story)
- The **research question**
- The 'proper' **theory**
- The **hypotheses?**

Example

- That's some descriptive evidence that could inspire an anecdote
- The **anecdotal argument** (think of a story)
 - My friend John who went on Erasmus has more money than my other friend who couldn't go, and also, John managed to get a job because his father is partner at a local firm
- The **research question**
 - Is there a causal effect of Erasmus on labor market early success? Is the effect mediated by household income?
- The 'proper' **theory**
 - Going on Erasmus does not have any causal effect on getting a first job, the relationship is explained by the confounding effect of income
 - Or: Positive effect among high-income students because they have access to informal networks where this experience is valued
- The **hypotheses?**

Hypotheses

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 - Which essentially means being able to say what you expect to see given a theory
And ideally, knowing what you need to see in order to discredit the theory
- Imagine that I have the theory that my knee hurts when I do sports on cold days
 - Simplifying it, we have a 2x2 situation:

Hypotheses: what would you expect to observe?

	<i>Cold day</i>	<i>Hot day</i>
<i>Run</i>		
<i>Didn't run</i>		

Hypotheses: what would you expect to observe?

	<i>Cold day</i>	<i>Hot day</i>
<i>Run</i>	Pain	Not pain
<i>Didn't run</i>	Not pain	Not pain

What if you observe this?

	<i>Cold day</i>	<i>Hot day</i>
<i>Run</i>	Pain	Not pain
<i>Didn't run</i>	Pain	Pain

- New theory?
- How would you test it?

Why bother with theory?

- Why start with questions and arguments?

Why not just exploit data? (Especially if we have big data)

Why bother about theory?

Teen Arrested in Samurai Killing

April 3, 2000



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MADRID, Spain (AP) — Police in southeastern Spain arrested a 16-year-old martial arts fan Monday for killing his parents and little sister with a samurai sword.

Police arrested the teen in a train station in Alicante as he and a friend were preparing to travel to Barcelona, said Jose Luis Rico, spokesman for the Alicante police.

Why bother about theory?

PORTADA | SOCIEDAD | SANIDAD

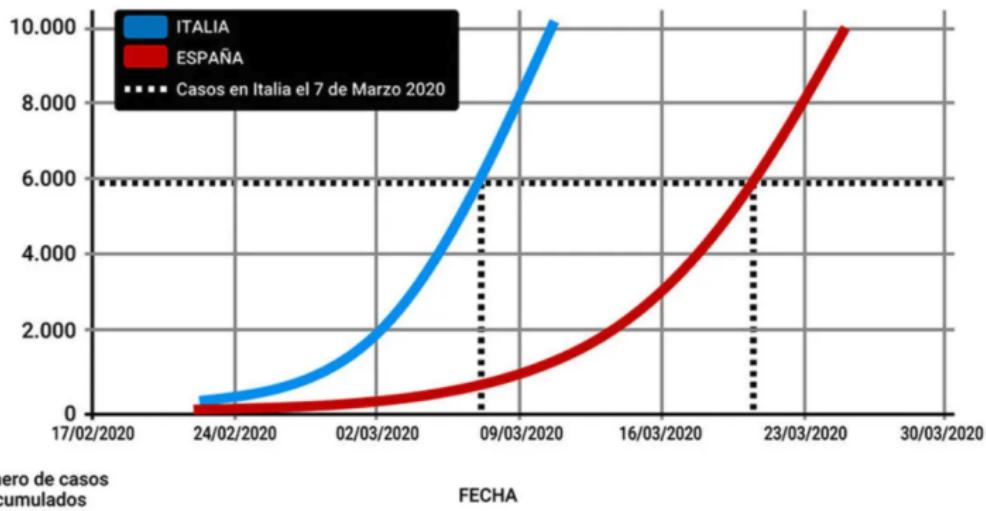
La curva del coronavirus: España podría ser la nueva Italia

niusdiario.es • Madrid

10/03/2020 • 05:30h.



CORONAVIRUS COVID-19 ESPAÑA vs ITALIA



Computational methods and theory

- Limitations of *data mining*
- Focus on the what rather than on the why
- Problems with machine learning
 - Example of predicting ice cream sales

Why bother about theory?

CIVIL UNREST

Predicting Civil Conflict: What Machine Learning Can Tell Us

Computer programs can be used as early warning systems, allowing the global community to act before violence erupts.

Mechanisms briefly

- A **mechanism** is basically the **how** (or why) of a relationship
- e.g., we know that the flu gives us fever
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Mechanisms briefly

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- e.g., we know that the flu gives us fever
 - flu > fever
- What's the mechanism?
 - flu > *immune system detects infection* > Δ body temp > fever
- Good think about mechanisms is that we can try to test them

Testing mechanisms (\approx sub-research questions)

- Let's go back to the Erasmus example
- If our theory is that the effect of going on Eramus is higher for high-income students due to their access to social networks,
what's the mechanism?
- And how could we try to **test it?**
→ (Think about the sub-RQs)

Recap

- Questions on theory, RQ, or mechanisms?

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Example: Wartime civilian deaths

Paper discussion

Concepts

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Measurement issues

1. Measuring what you really want to measure
 - Careful with the use of proxies
2. Choosing the right unit of analysis
 - Depends on the theory
3. Keep in mind what units you're not observing
 - Missing data, sampling bias

Measuring the right stuff

- Not a lot to say here, other than to **pay attention**
- We normally look at one variable superficially without thinking about how it was created
- How was it exactly measured?
 - Survey wordings
 - Coding issues (e.g. level of democracy)
 - Type of raw data used
- And more importantly, are there **biases related to our question?**

Measuring the right stuff: Example

EXAMPLE FROM THE DEMOCRATIC BACKSLIDING LIT?

Proxies

- A **proxy variable** is a variable that we use to substitute another variable we cannot observe or measure
- This is a matter of creativity, but the important thing is to think about **potential biases**
- A real example:
 - Trying to know if leftist/Basque nationalist priests during Francoist Spain had an effect on later terrorism
 - First problem (among many): how do you measure the ideology of these people?
 - Using the 1963 letter to the Vatican

Latent variables

- Some concepts are just not directly observable
→ (or very expensive / unfeasible to do so)
- Another option is to create the variable out of other observables
- This is sometimes called **latent variables**

Latent variables

EXAMPLE TWITTER LATENT IDEOLOGY

Unit of analyses

- Level at which we have our observations
- Deeply related to the variables we have
 - Even though not all variables have to/can be measured at the same level

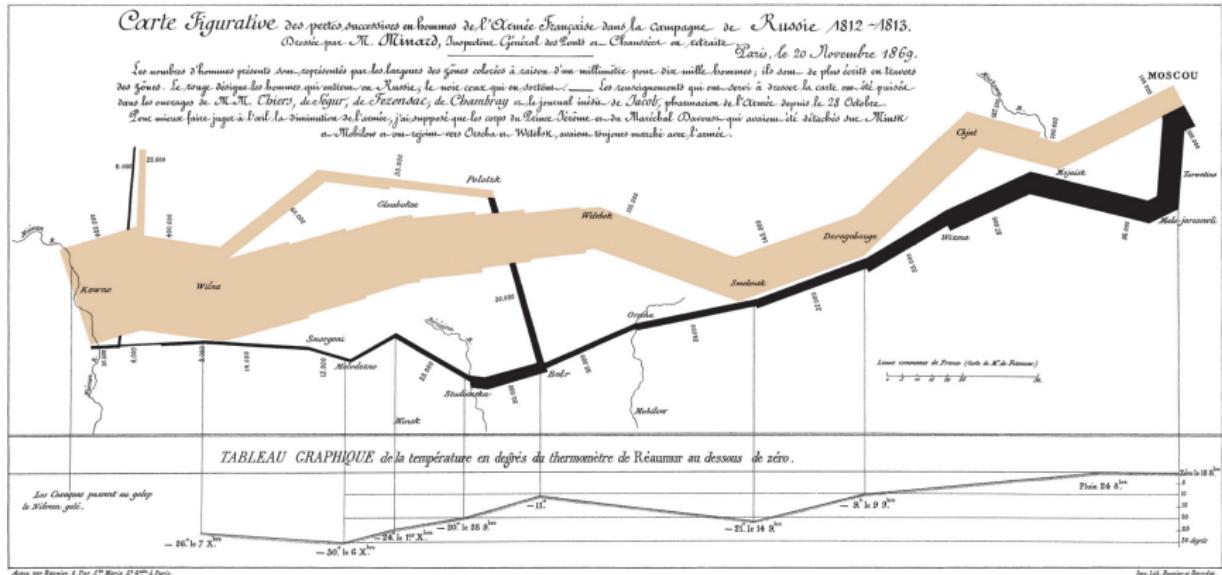
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Unit of analyses

- Level at which we have our observations
- Deeply related to the variables we have
 - Even though not all variables have to/can be measured at the same level
 - e.g. individual-level data and household income
- Most important thing: we need to **choose the right unit of analyses** depending on the theory (and mechanism) we are testing

A more difficult example



- How many variables and what's the unit of observation?

Extra: What's the causal argument being told here?

Could we test it with the data we have?

Theories, hypotheses, and measurement

- Let's say I want to explain the effect of school choice on future salaries
- My argument is: going to private schools leads to higher salaries in the future because increased resources lead to better educational attainment through lower teacher/pupil ratio, which signals individuals as more skillful in the labour market, explaining higher salaries

Theories, hypotheses, and measurement

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- Hypotheses?

Theories, hypotheses, and measurement

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- Hypotheses?
- Testing the relationship and the mechanism?
And alternative explanations?

Another example



Percentage of years in which the 'Great Powers' fought one another, 1500–2015 – by Max Roser

Between 1500 and today there were more than 50 wars between 'Great Powers'.

Data are aggregated over 25-year periods.

The Great Powers:

Entire period – France and England/Great Britain/U.K.

Since 1949 – China

Since 1898 – USA

Since 1740 – Germany/Prussia

Since 1721 – Russia/USSR

1905 to 1945 – Japan

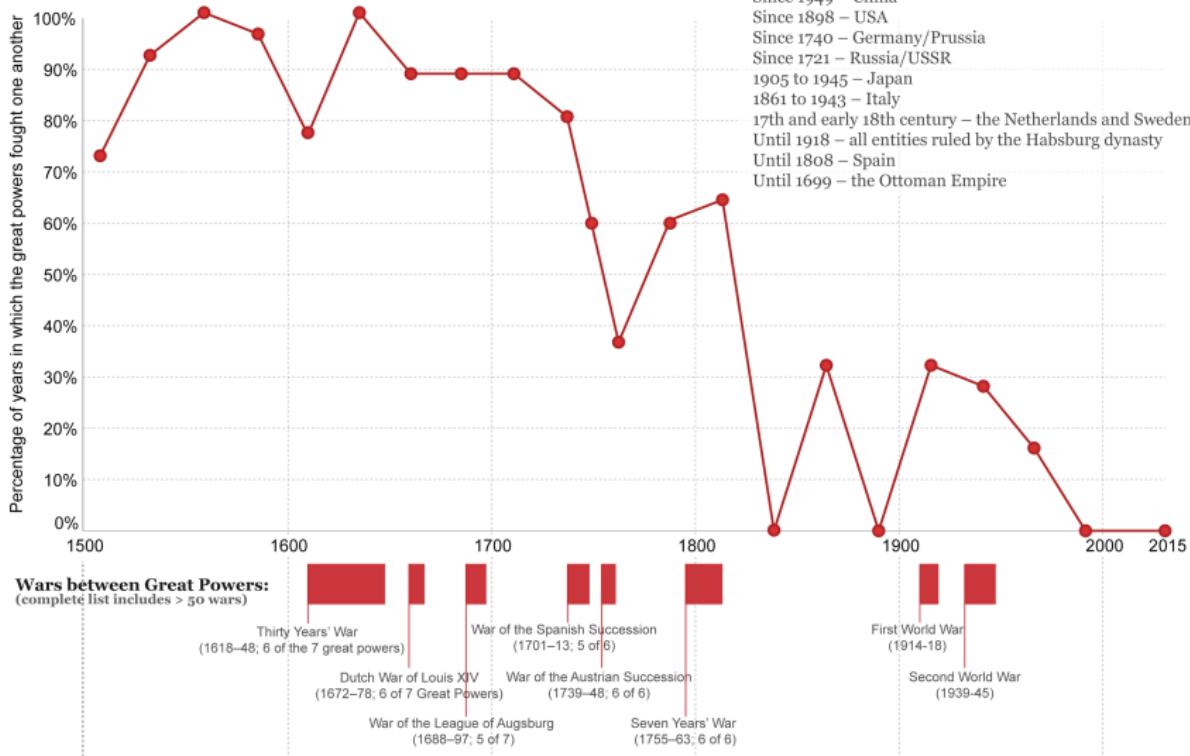
1861 to 1943 – Italy

17th and early 18th century – the Netherlands and Sweden

Until 1918 – all entities ruled by the Habsburg dynasty

Until 1808 – Spain

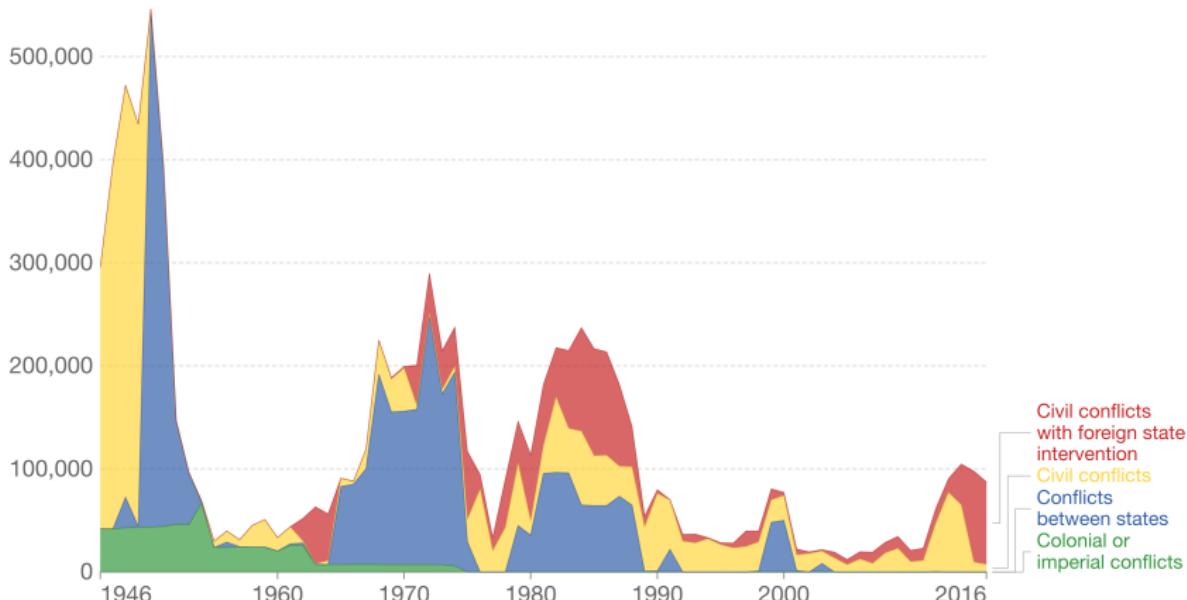
Until 1699 – the Ottoman Empire



Another example

Battle-related deaths in state-based conflicts since 1946, 1946 to 2016

Only conflicts in which at least one party was the government of a state and which generated more than 25 battle-related deaths are included. The data refer to direct violent deaths. Deaths due to disease or famine caused by conflict are excluded. Extra-judicial killings in custody are also excluded.



Source: UCDP/PRIO

Note: The war categories paraphrase UCDP/PRIO's technical definitions of 'Extrasystemic', 'Internal', 'Internationalised internal' and 'Interstate' respectively. In a small number of cases where wars were ascribed more than one type, deaths have been apportioned evenly to each type.

CC BY

Another example

- Now, let's say my theory is that inter-state war has declined because democratic countries are less likely to go to war because they face higher domestic costs for waging wars
- Hypotheses? Testing the mechanism? Unit of analyses?
Measurement? Alternative explanations?

Another example

- What if I say that it is because democracies do not fight *each other*, as they have shared interests in the international system and shared conflict resolution mechanisms?
- And if I say that democratic countries face higher costs when fighting another democracy, but not otherwise?
- What should I observe in each case? At different levels? How to measure?

Beyond our observations: missing data

- **Missing data** is often more important than it looks
- Important to understand if it's biasing our analyses
- Three types:

1. Missing **completely at random**

- No problem, random observations are missing
(Probably not very often)

2. Missing **at random**

- One variable explains whether obs are missing or not, but it's not related to our question

3. Missing **not at random**

- The variable that explains 'missingness' is key to our question

EXAMPLES? WITH DAGS?

Beyond our observations: sampling bias

- **Sampling bias** could be thought of as missing data or, rather, as a controlling variable we'll indirectly include
- Easy case: we're dealing with a pre-designed sample that might have some biases
 - Online survey and +65
- More easy to miss: there is an 'invisible' determining which observations we have or not
 - e.g. when using Twitter data,
- We'll talk more about how this affects inference
 - Collider bias example?

Complexity of the social world and micro/macro



- Why do mass protests emerge?

Levels of explanation

Can you think of...?

- Macro-level mechanisms
- Micro-level mechanisms

Levels of explanation

Can you think of...?

- Macro-level mechanisms
- Micro-level mechanisms
- What's the point of macro-level explanations, actually?

Extra: From qualitative to quantitative

- Imagine you have this question:
What are the differences between neoclassicism and romanticism in music?
- Could you try to make a quantitative question out of it?

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Describing variables

- What is a **variable**?
- Types?

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Describing variables

- What is a **variable**?
- Types?
 - Continuous
 - Count
 - Ordinal
 - Categorical (binary)
 - Qualitative (* are really a variable?)
- Why does it matter?
- Conceptual meaning vs statistical meaning

Describing variables

main idea: variable distribution (of values)

you probably know this because of basic statistics. it doesn't matter so much

kurtosis, normality, blah blah

but one thing though: values are real-world observations. do **plot** it, and make sure it's coherent with the **theoretical** or **expected distribution**

maybe also important: mean +/- SD, or 25/75 percentiles. for effect sizes

in a normal distribution, there not much to say. but e.g. if an independent variable is a bimodal distribution, does that say something about the causal mechanism?

e.g. think about the effect of income on X, in a super unequal society vs one in which is normally distributed

Describing relationships

- What is a **relationship**?
- Essentially that as you know about the values of one variable, you learn about the values of the other variables
 - e.g. a *negative* relationship means that you know that higher values in x imply lower values in y

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Imagine you have a small car, and a friend of yours is coming and is bringing along his two kids. Concerned about space, you ask '*how old are they?*' And the answer is: '*They're 6 and 2.*'

→ What do you imagine about size?

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Imagine you have a small car, and a friend of yours is coming and is bringing along his two kids. Concerned about space, you ask '*how old are they?*' And the answer is: '*They're 6 and 2.*'

- What do you imagine about size?
- Now imagine you ask '*are they blonde, red-haired, or brown-haired?*'

Statistical relationship \neq causal relationships

- Last example: Is there a causal relationship $age \rightarrow size$?

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- What if the variable you want to guess is **the time of the day**, and someone tells you that she just heard the rooster crow? Causal?

Statistical relationship \neq causal relationships

- Last example: Is there a causal relationship $age \rightarrow size$?
- What if the variable you want to guess is **the time of the day**, and someone tells you that she just heard the rooster crow? Causal?
- Why are non-causal descriptive relationships **useful**?

Describing relationships

conditional distributions conditional means conditional conditional
means (controlling)

Univariate description

Facebook says there are only 3.57 degrees of separation

By James Titcomb

4 February 2016 • 10:06am



Univariate description

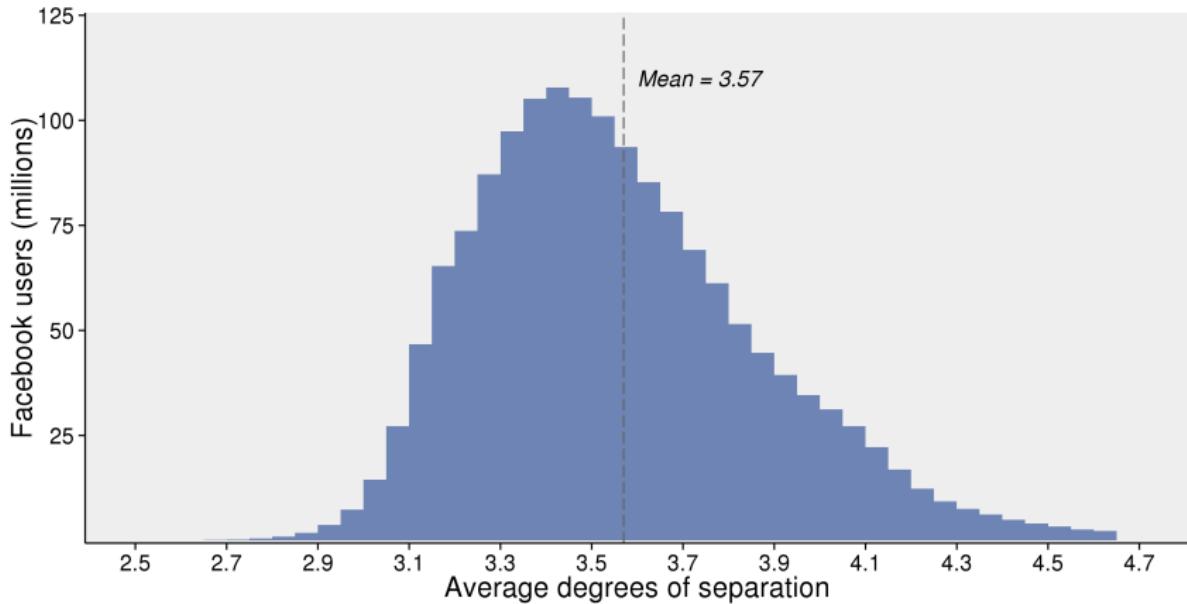


Fig 1. Estimated average degrees of separation between all people on FB.

(<https://research.facebook.com/blog/2016/2/three-and-a-half-degrees-of-separation/>)

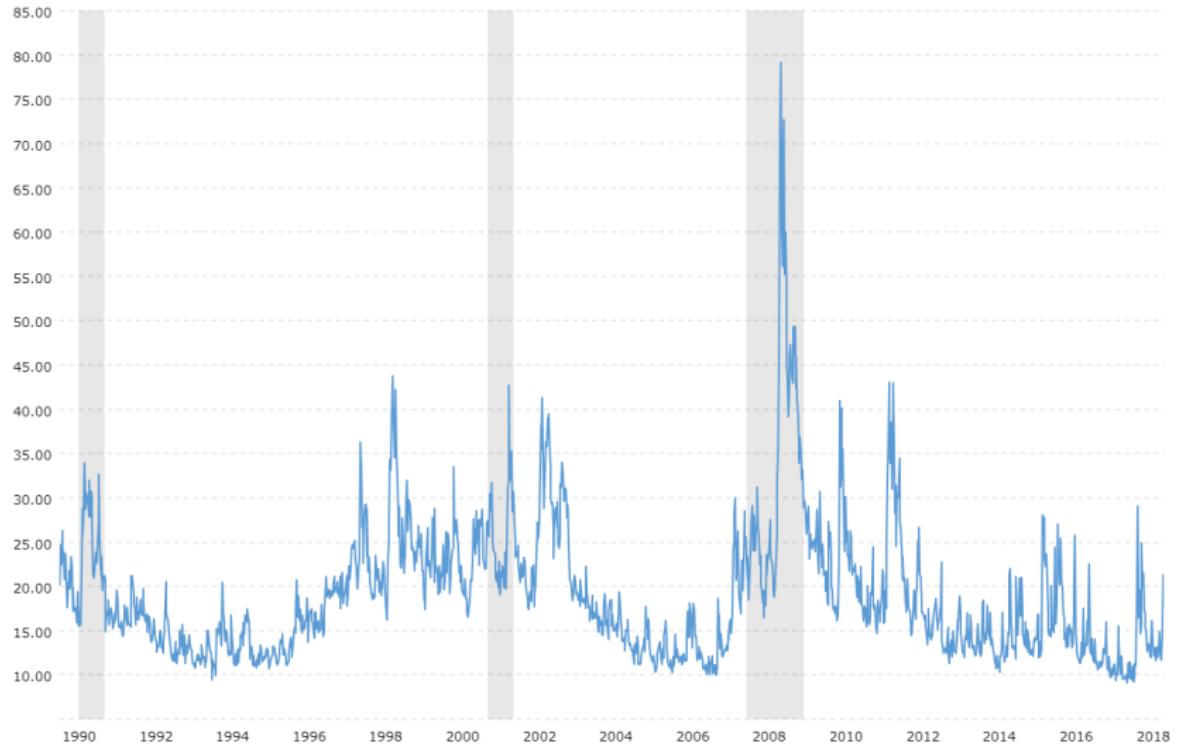
The original ‘theory’

I read somewhere that everybody on this planet is separated by only six other people. Six degrees of separation. Between us and everybody else on this planet. The president of the United States. A gondolier in Venice. fill in the names.

Six Degrees of Separation, John Guare

- Do we have an answer?

Univariate description?

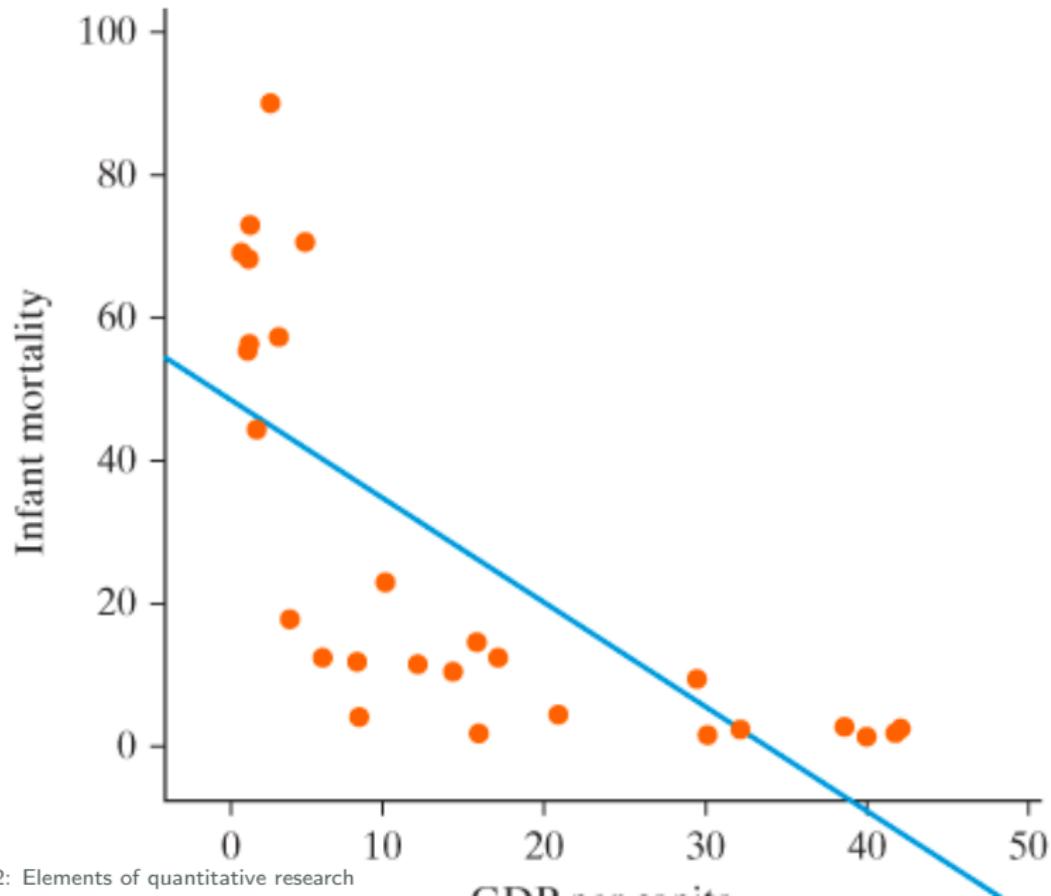


VIX Volatility Index chart

Bivariate relationships

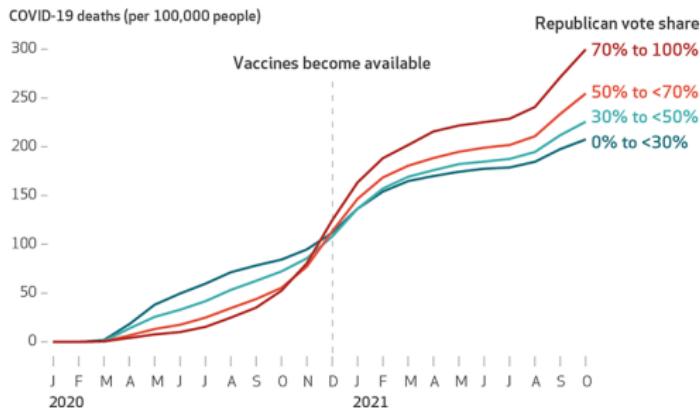
- Examples?

Bivariate relationship



How many variables? Unit?

Cumulative COVID-19 deaths per 100,000 people, by county proportion of Republican presidential popular vote in the 2020 election, January 1, 2020–October 31, 2021



Neil Jay Sehgal et al. Health Affairs. 2022;41(6):859

©2022 by ProjectHOPE - The People-to-People Health Foundation, Inc.

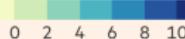
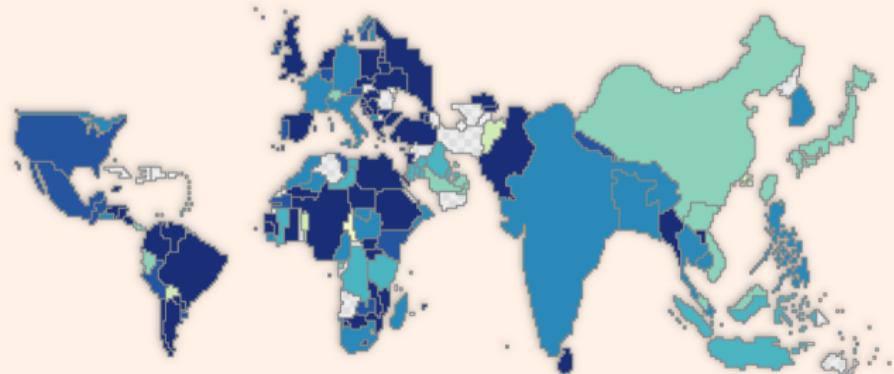
HealthAffairs

How many variables? Unit?

A population-adjusted snapshot of global inflation

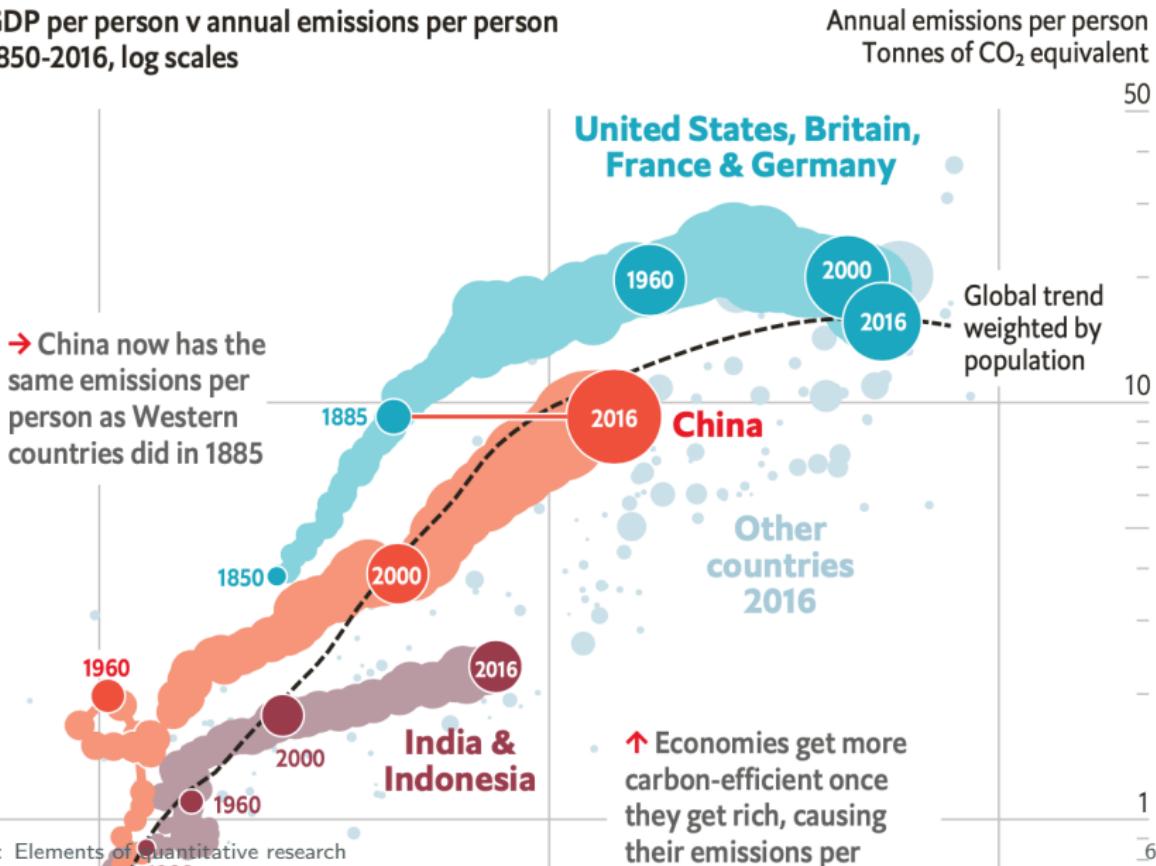
Annual % change in consumer price indices, latest figures available (select a country for details).

Each country on the map is sized according to total population in 2018

 Search..

How many variables? Unit?

GDP per person v annual emissions per person
1850-2016, log scales



Bivariate relationships

- What do we use this for?

Bivariate relationships

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- Essentially, we are trying to detect whether two variables are dependent
 - In other words, it's about conditional values: $E(Y|X)$

Bivariate relationships

- What do we use this for?
- Essentially, we are trying to detect whether two variables are dependent
 - In other words, it's about conditional values: $E(Y|X)$
- Example graph about infant mortality:
 $E(IM|GDPpc = 1000)?$
 $E(IM|GDPpc = 30000)?$

Bivariate relationships

- This is what statistics is about, and only this

Bivariate relationships

- This is what statistics is about, and only this
- Even if it can get complicated: non-linear relationships, multivariate dependencies, etc

Bivariate relationships

[nature](#) > [nature communications](#) > [articles](#) > [article](#)

Article | [Open Access](#) | Published: 20 August 2018

Sequences of purchases in credit card data reveal lifestyles in urban populations

[Riccardo Di Clemente](#), [Miguel Luengo-Oroz](#), [Matias Travizano](#), [Sharon Xu](#), [Bapu Vaitla](#) & [Marta C. González](#) 

[Nature Communications](#) **9**, Article number: 3330 (2018) | [Cite this article](#)

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 This article has been [updated](#)

Abstract

Zipf-like distributions characterize a wide set of phenomena in physics, biology, economics, and social sciences. In human activities, Zipf's law describes, for example, the frequency of appearance of words in a text or the purchase types in shopping patterns. In the latter, the uneven distribution of transaction types is bound with the temporal sequences of purchases

of individual choices. In this work, we define a framework using a text compression technique

Bivariate relationships

RESEARCH ARTICLE

Faces in the crowd: Twitter as alternative to protest surveys

Christopher Barrie^{1*}, Arun Frey^{2,3}

¹ School of Social & Political Science, University of Edinburgh, Scotland, United Kingdom, ² Department of Sociology, University of Oxford, England, United Kingdom, ³ Leverhulme Centre for Demographic Science, Oxford, England, United Kingdom

● All these authors contributed equally to this work and are listed in alphabetical order.

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Abstract

Who goes to protests? To answer this question, existing research has relied either on retrospective surveys of populations or in-protest surveys of participants. Both techniques are prohibitively costly and face logistical and methodological constraints. In this article, we investigate the possibility of surveying protests using Twitter. We propose two techniques for sampling protestors on the ground from digital traces and estimate the demographic and ideological composition of ten protestor crowds using multidimensional scaling and machine-learning techniques. We test the accuracy of our estimates by comparing to two in-protest surveys from the 2017 Women's March in Washington, D.C. Results show that our Twitter sampling techniques are superior to hashtag sampling alone. They also approximate the ideology and gender distributions derived from on-the-ground surveys, albeit with some bias, but fail to retrieve accurate age group estimates. We conclude that online samples are

Describing relationships

- When we find a conditional relationship, we often say that X *explains* Y
- But these statistical relationships do *not* tell us anything about cause and effect, only about conditional means (or $E(Y|X)$, or conditional conditional means if we also control for Z)
- We need another strategy to understand *why*

Explanatory questions and data

- Let's we want to know what's going on between two things (the process or mechanism between two variables)
- Data always comes from somewhere
- So when we look at or analyze data, we try to uncover the *data generating process*
 - There could be several mechanisms generating the same data (variable), or they might vary over time
- (A model is actually our simplified guess of that process)

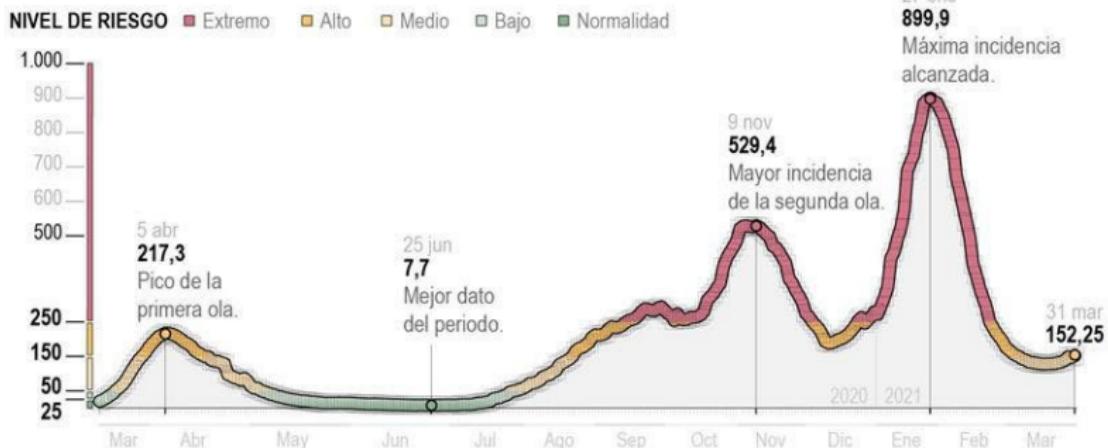
Data generating process

- How does the data look like, and what's the data generating process in...
 - Flipping a coin?
 - Choosing Mahou instead of another beer brand?
 - Going on Erasmus and getting a job?

Data generating process

Evolución de la incidencia acumulada en España

Casos diagnosticados en los últimos 14 días por cada 100.000 habitantes.

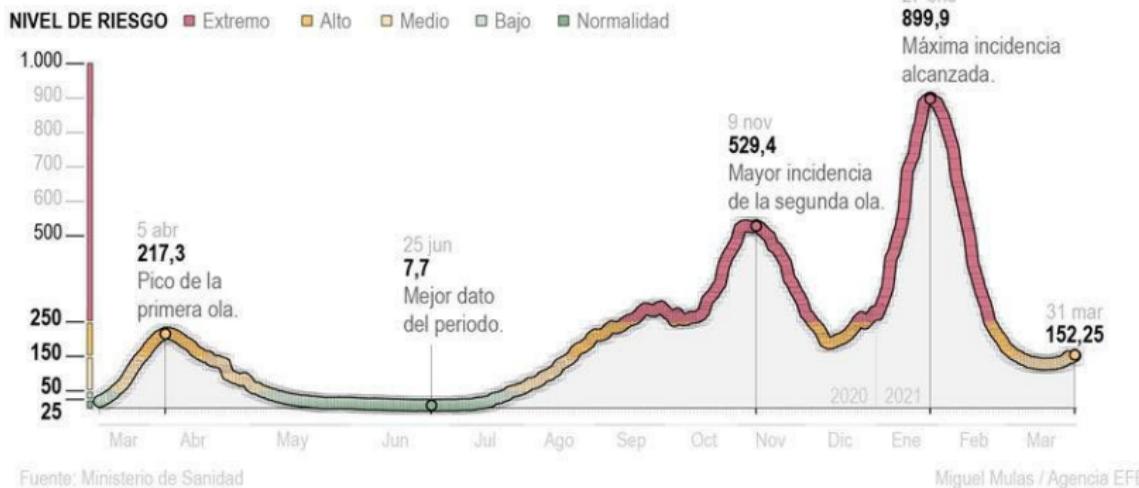


- What the generating process?

Data generating process

Evolución de la incidencia acumulada en España

Casos diagnosticados en los últimos 14 días por cada 100.000 habitantes.



- What the generating process?
- How many variable are involved in generating this outcome?

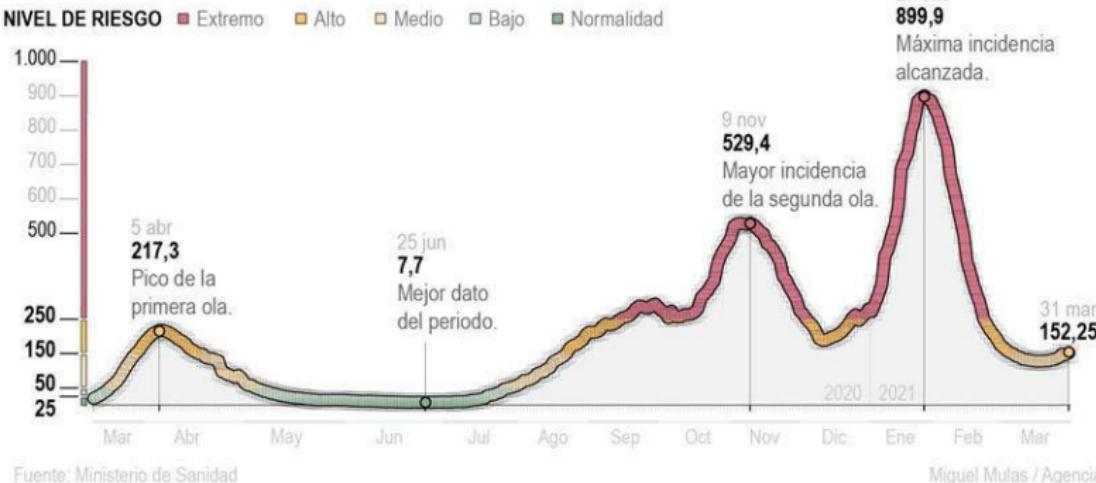
Thinking about variables and processes/mechanisms

- Think we explain or explain with: variables
- Relationship between them: process
- The main idea is that if we compare different combinations of their values we are going to discover something about the process

Data generating process

Evolución de la incidencia acumulada en España

Casos diagnosticados en los últimos 14 días por cada 100.000 habitantes.

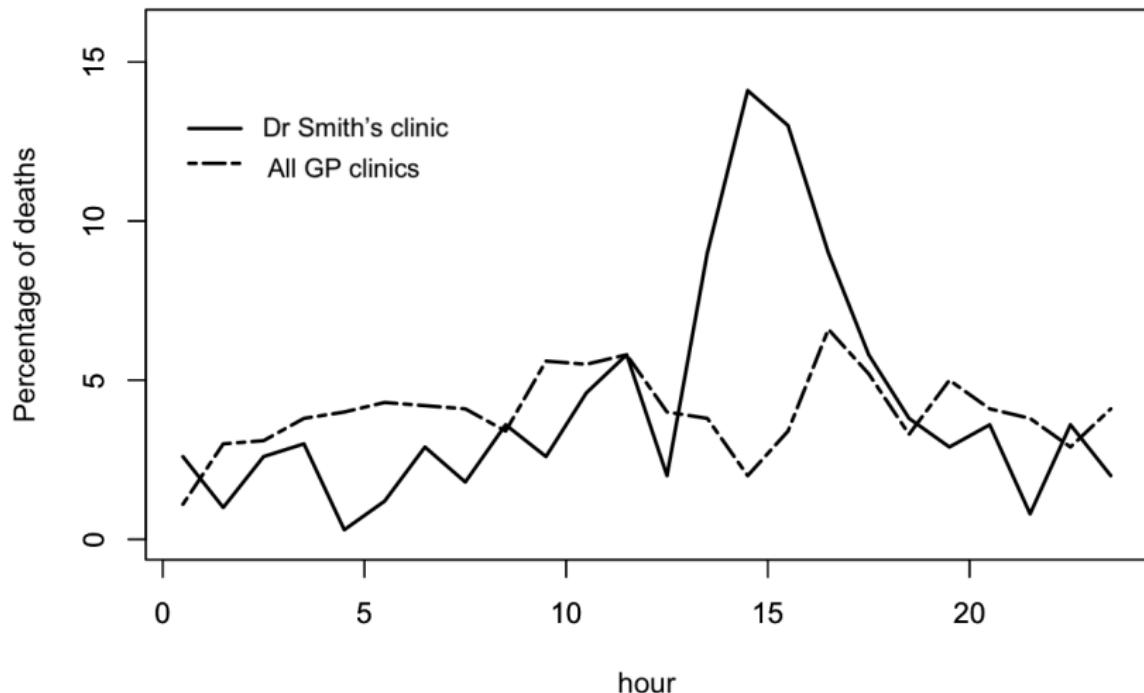


- How could we test different hypotheses? (schools, bars, weather, etc)

DGP and RQs

- Again, we want to state the research question as close as possible to that generating process
 - What explains Covid incidence in Madrid?
 - What explains Covid incidence in Madrid over time between June 2020 and June 2021
 - Do school openings increase Covid incidence in Madrid?
 - School openings and Covid incidence evolution in Madrid

Example



Roadmap

Theories and research questions

Concepts and operationalization

Measurement

Describing variables and relationships

Prediction

Example: Wartime civilian deaths

Paper discussion

About prediction

- What is prediction?

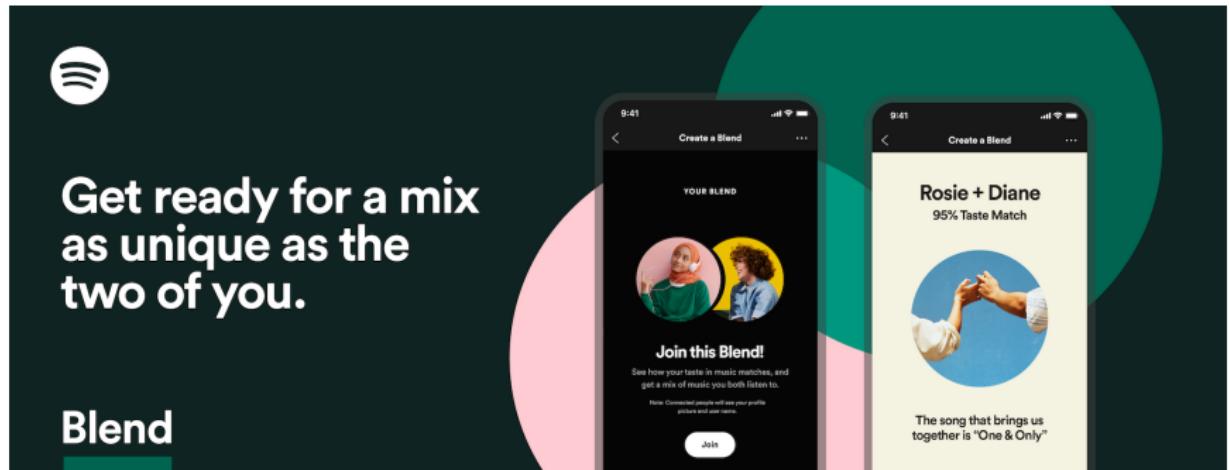
About prediction

- What is prediction?

The two concepts of prediction:

- Predicting another variable
- Predicting the future (or out of sample prediction)

About prediction



About prediction

TECH

How Target Figured Out A Teen Girl Was Pregnant Before Her Father Did

Kashmir Hill Former Staff

Welcome to *The Not-So Private Parts where technology & privacy collide*

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Feb 16, 2012, 11:02am EST

About prediction

ECONOMICS

Predicting poverty and wealth from mobile phone metadata

Joshua Blumenstock,^{1*} Gabriel Cadamuro,² Robert On³

Accurate and timely estimates of population characteristics are a critical input to social and economic research and policy. In industrialized economies, novel sources of data are enabling new approaches to demographic profiling, but in developing countries, fewer sources of big data exist. We show that an individual's past history of mobile phone use can be used to infer his or her socioeconomic status. Furthermore, we demonstrate that the predicted attributes of millions of individuals can, in turn, accurately reconstruct the distribution of wealth of an entire nation or to infer the asset distribution of microregions composed of just a few households. In resource-constrained environments where censuses and household surveys are rare, this approach creates an option for gathering localized and timely information at a fraction of the cost of traditional methods.

About prediction

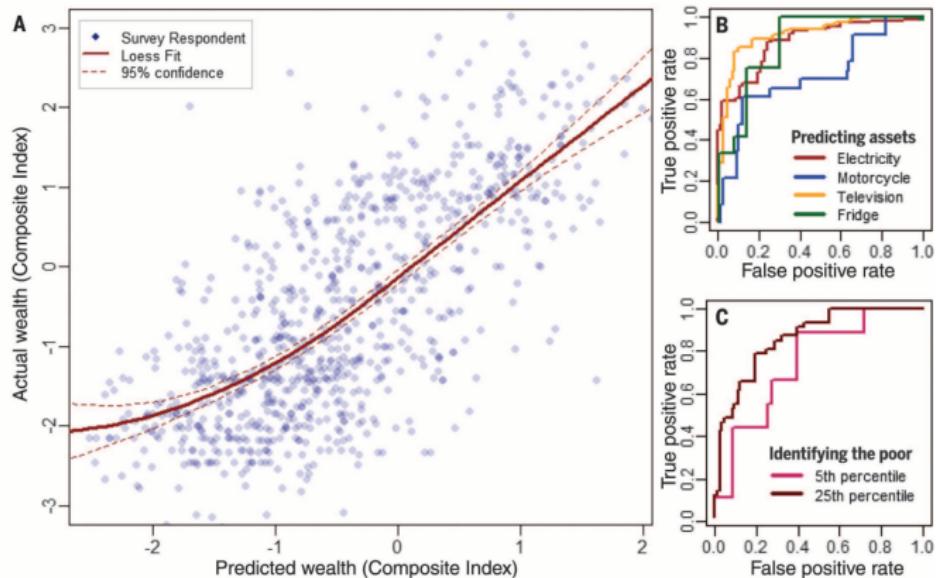


Fig. 1. Predicting survey responses with phone data. (A) Relation between actual wealth (as reported in a phone survey) and predicted wealth (as inferred from mobile phone data) for each of the 856 survey respondents. (B) Receiver operating characteristic (ROC) curve showing the model's ability to predict whether the respondent owns several different assets. AUC values for electricity, motorcycle, television, and fridge, respectively, are as follows: 0.85, 0.67, 0.84, and 0.88. (C) ROC curve illustrates the model's ability to correctly identify the poorest individuals. The poor are defined as those in the 5th percentile (AUC = 0.72) and the 25th percentile (AUC = 0.81) of the composite wealth index distribution.

About prediction

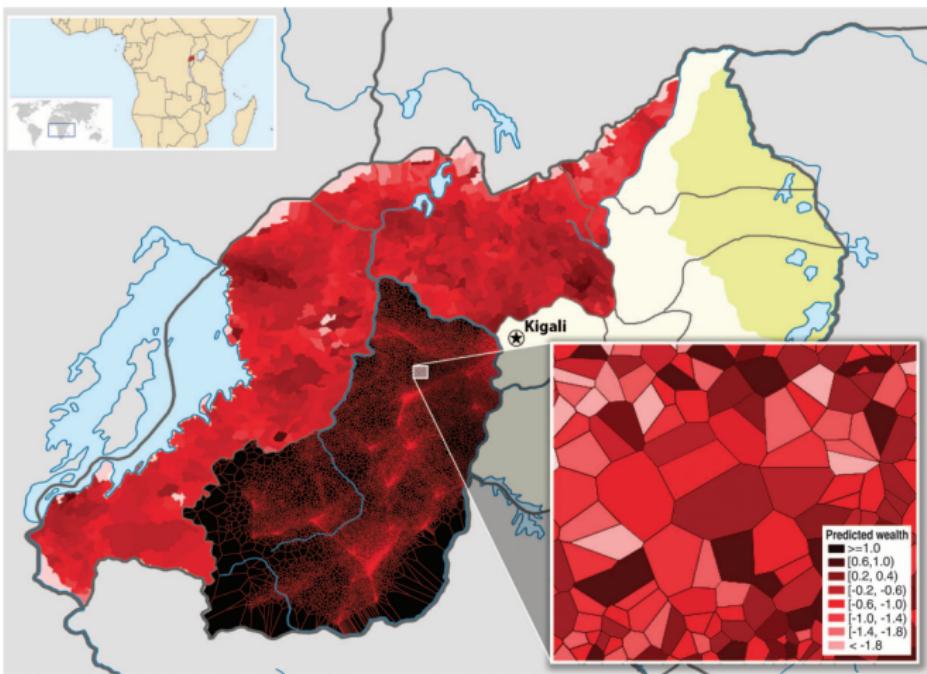


Fig. 2. Construction of high-resolution maps of poverty and wealth from call records. Information derived from the call records of 1.5 million subscribers is overlaid on a map of Rwanda. The northern and western provinces are divided into cells (the smallest administrative unit of the country), and the cell is shaded according to the average (predicted) wealth of all mobile subscribers in that cell. The southern province is overlaid with a Voronoi division that uses geographic identifiers in the call data to segment the region into several hundred thousand small partitions. (**Bottom right inset**) Enlargement of a 1-km² region near Kiyonza, with Voronoi cells shaded by the predicted wealth of small groups (5 to 15 subscribers) who live in each region.

About prediction

- Causality and prediction, is it the same?

About prediction

- Causality and prediction, is it the same?
- The importance of **counterfactuals** (more on this later)

Roadmap

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Paper discussion

Practical example

- You want to test an argument about **wartime civilian deaths**:
 - The intuition you have is that civilians will be more likely to be treated well (and not killed) by rebel groups during civil wars when they need their resources (e.g. labor) to survive
- Clean up the theory, decide on the main concepts
- Develop different RQ at different levels
- How can we measure the main concepts? Variables?
- What answers could we get from the data?
 - Are we learning something about our theory?

Roadmap

Theories and research questions

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Example: Wartime civilian deaths

Paper discussion

Roads to Rule, Roads to Rebel: Relational State Capacity and Conflict in Africa

Journal of Conflict Resolution

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and Lars-Erik Cederman³

Abstract

Weak state capacity is one of the most important explanations of civil conflict. Yet, current conceptualizations of state capacity typically focus only on the state while ignoring the relational nature of armed conflict. We argue that opportunities for conflict arise where relational state capacity is low, that is, where the state has less control over its subjects than its potential challengers. This occurs in ethnic groups that are poorly accessible from the state capital, but are internally highly interconnected. To test this argument, we digitize detailed African road maps and convert them into a road atlas akin to Google Maps. We measure the accessibility and internal connectedness of groups via travel times obtained from this atlas and simulate road networks for an instrumental variable design. Our findings suggest that low relational state capacity increases the risk of armed conflict in Africa.