ORIE 5355: Applied Data Science - Decision-making beyond Prediction

Lecture 2: Common challenges in data collection

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Announcements

- Homework 1 posted soon, due 9/17
- Please fill out:
    - When2meet for office hours
    - Pre-course survey
    - Homework buddy form

Questions from last time?

Module overview

- What *is* data? Where does it come from? What does it *represent?*
- Common challenges in data collection

  Selection biases, censoring, and other challenges
- Polling/surveys as an extended example
  - What goes wrong in measuring opinions (mean estimation)
  - Some techniques that somewhat work
  - US 2016 election polls as a case study
- Other challenges and contexts: online ratings, privacy, etc.

What is data?

A quick primer on measurement theory

What is a quantitative data point?

A measurement is “**assignment** of numbers to a **variable** in which we are interested.”

- Construct/variable: what are we actually interested in?
- measurement/datum: numerical representation

These are not the same thing, especially with complexities of people!

Examples of constructs and (often flawed) measurements

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Your political views/ideal public policy	Reduced to binary choice in voting
Race + Ethnicity	“white,” “Black,” “Asian” “Hispanic” “Other”
Gender	Often reduced to binary in surveys/forms

People disagree on how measurements map to constructs

- Ratings in online marketplaces across countries
  - In the US, anything but 5 stars means “terrible.”
  - In other countries, 3 or 4 stars is the norm
  - Heterogeneity within a country/culture: some people rate everything a 5 and always tip, others never do
- What do political terms mean?
  - Hakeem Jefferson, “The Curious Case of Black Conservatives: Construct Validity and the 7-point Liberal-Conservative Scale.”

Why does this matter?

- You’re AirBnB
  - Do you have the same threshold for badges/`high quality’ across countries?
  - People travel across countries, how do you standardize their ratings?
  - How do you communicate ratings to people from different cultures?
- You’re doing a regression and trying to predict political leaning
  - When someone says they are “for environmental protection,” does that mean they support raising taxes on fuel? Preventing housing to save the turtles? Government funding of clean energy?
  - Do you do something different for Black people who say they’re conservative versus white people who do so?
- You collect reports on problems in a city (311). What does it mean when someone reports an “unacceptable” pothole to fix? Can you trust that different people are reporting problems at the same rates?

What to do about it?

When *collecting* data, you can opt for free form text to give flexibility

- Doesn’t constrain people to your pre-determined categories
- Potentially allows people to add more detail to capture the “construct”

This makes *analyzing* the data harder; doesn’t fully solve the problem

- Most machine learning methods take in numeric or categorical data
- Even most modern NLP techniques convert words to numbers (“embeddings”)
- Doesn’t solve the problem of people using the same words to mean different things

=> this is a fundamental issue with quantitative data analysis

Ok, so what *can* you do?

You’re going to have to make measurement choices at some point. Best make them consciously than by default.

- What is the data going to be used for? Do you need to create categories if there isn’t a downstream prediction task?
- Categories chosen should relate to downstream tasks

  “Hispanic/Latino” category:

  - To know what languages to support, need to separate “Brazilian”
  - To predict political lean, separate out “Cuban in Florida”
- Some measures are more consistent than others

  Ask about more “objective” traits such as responsiveness or cleanliness

Parting thoughts about constructs

- Quantitative data science is all about creating general beliefs about discrete categories

  Also known as “stereotyping,” and data science inherits all its problems

- Be thoughtful about whether the measurement you have is appropriate for the construct you care about
- Many of the challenges we’ll discuss in this class are just the measurement-construct dichotomy in disguise

  [You really care about X, but the data you have can only tell you Y]

Questions?

Mean estimation from surveys

The task

- Each person j has an opinion, $Y_j \in \{0, 1\}$
- We want to measure $\bar{y} = E[Y_j]$, the population mean opinion on some issue
- Each person also has covariates, x_j^k
- We also may care about *conditional* means

$$E[Y_j \,|\text{ORIE program}]$$

Example:

"Do you like the class so far?"

Options: "yes" and "no"

$\bar{y}$: What fraction of people like the class so far?

Degree program, whether you like waking up at 9:30, etc

Fraction of people in ORIE who like the class

This problem is everywhere

- What fraction will vote for the Democrat in the next election?
- What is the average rating of this product?
- Do people want the city to build a foot bridge to Manhattan?
- Are people happy with this new feature I just deployed?

Naïve method

- Get list of people (watched the movie; from phone book)
- Call them, suppose everyone answers and get Y_j from each
- We now have $\{Y_j\}_{j=1}^{N}$, if called N people

Random samples of people in this class

- Simply do, $\hat{y} = \frac{1}{N}\sum_j Y_j$

Average opinion of the sample

- By law of large numbers, if Y_i is independent and identically distributed according to the true population's opinion, then
$$\hat{y} \rightarrow \bar{y} \text{ as } \mathrm{N} \rightarrow \infty$$

$\bar{y}$: Actual opinion of the class

What goes wrong

People don’t give “true” opinion

Why?

- You’re asking about something sensitive
- “social desirability” – people like making other people happy
- They’re getting paid to answer the survey and just want to finish
- You know they other person is also going to rate you

Of course, then you’re (likely) not going to succeed

People gave you $\widetilde{Y}_j$, instead of Y_j

$\hat{y} = \frac{1}{N} \sum_j \widetilde{Y}_j$

You lie because you want a better grade

$\hat{y}$ does not converge to $\bar{y}$, *unless errors cancel out*

Your sample does not represent your population

- You just posted a poll on Facebook or Twitter, anyone could respond
- You called only landlines, and no one under 50 owns one anymore
- You only asked people to rate a movie after they’ve seen it
- You can only rate an item if you bought it *and didn’t return it*
- Those with certain opinions are more likely not to answer
    - After bad experiences on online platforms
    - “Shy Trump voters” (?)

=> People who answer the poll are different than your population – “differential non-response”

Your sample does not represent your population, in math

- For each person j, let $A_j \in \{0,1\}$ be whether they answered
- You have $\boldsymbol{Y} = \left\{(A_j, Y_j)\right\}_{j=1}^{N}$, if called N people

  Where $Y_j = \emptyset$ if $A_j = 0$ (they did not answer)
- Again, you do

$$\hat{y} = \frac{1}{|\{j \mid A_j=1\}|} \sum_{j\in\{j \mid A_j=1\}} Y_j$$

where $\{j \mid A_j = 1\}$ denotes the set of people who answered

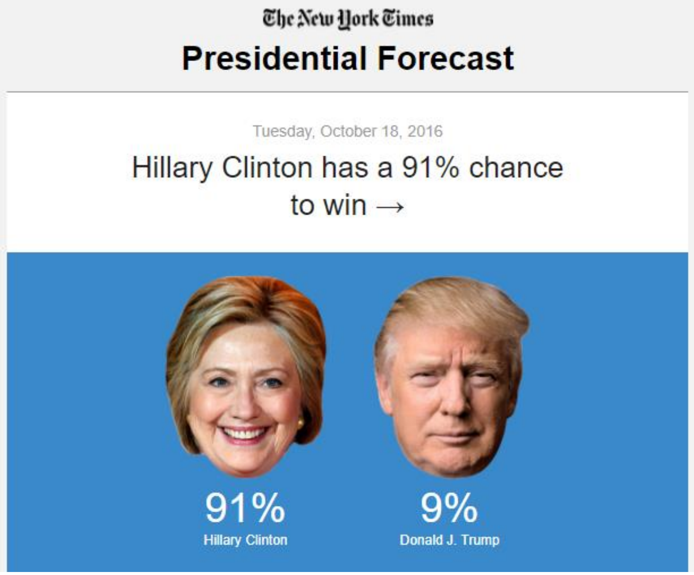
and so $|\{j \mid A_j = 1\}|$ is the number of people who answered

$\hat{y}$ does not converge to $\bar{y}$ *unless* Y_j and A_j are uncorrelated

Uncorrelated: Whether you answered is unrelated to what your true opinion is

Case study: Polling in US 2016 presidential election

Polls were off (a bit) in the 2016 e



The New York Times

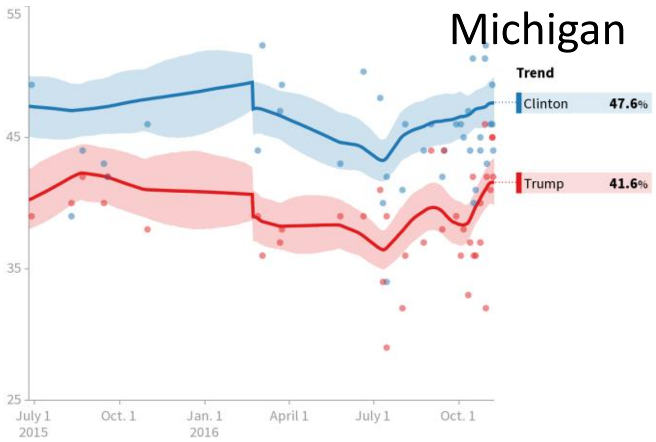
Presidential Forecast

Tuesday, October 18, 2016

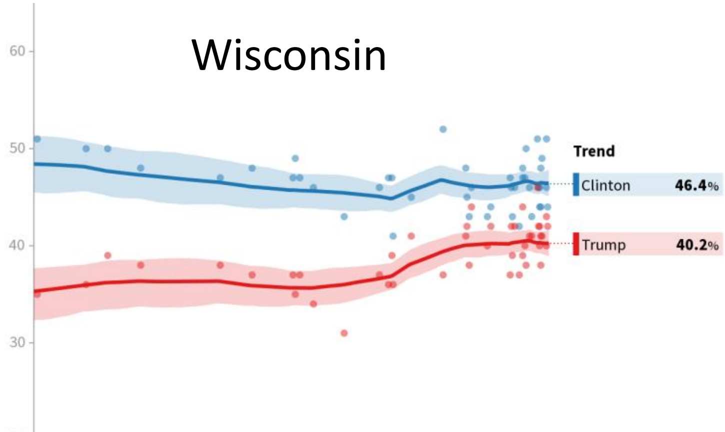
Hillary Clinton has a 91% chance to win →

91% Hillary Clinton

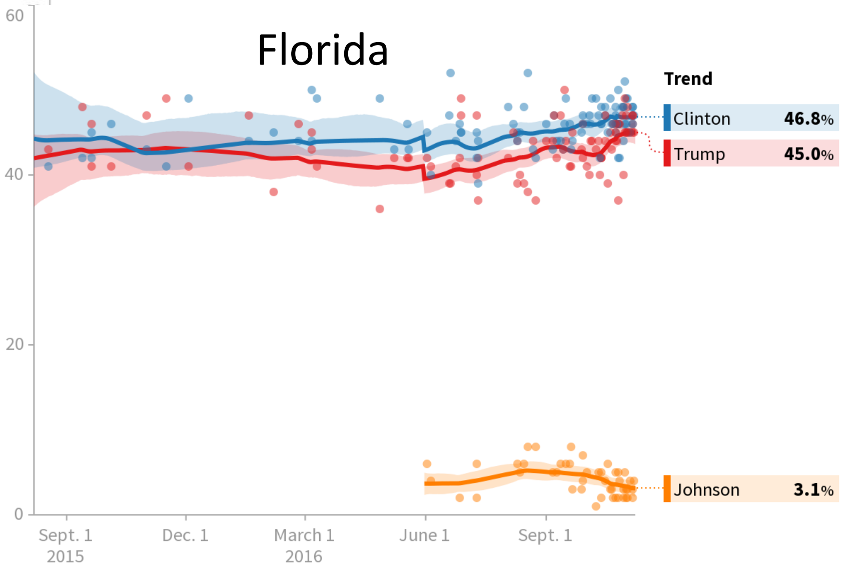
9% Donald J. Trump



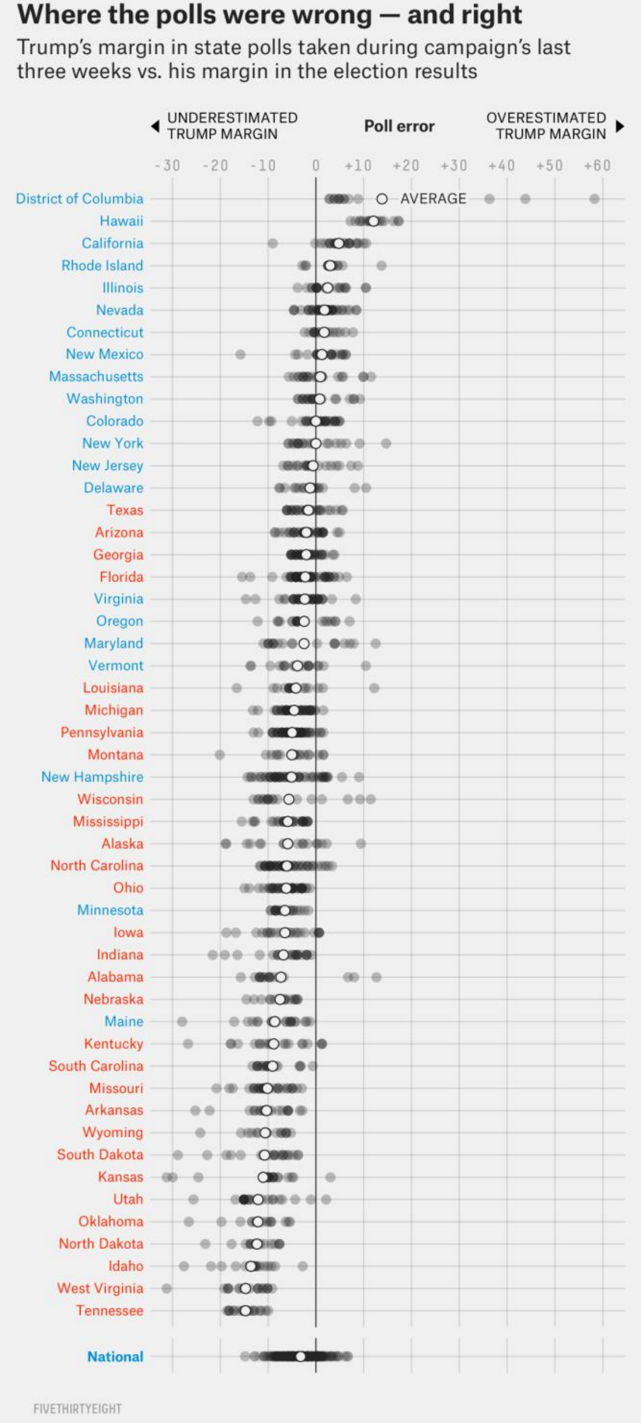
Michigan



Wisconsin



Florida



Where the polls were wrong — and right

Trump's margin in state polls taken during campaign's last three weeks vs. his margin in the election results

What happened?

- Professional pollsters spend a lot of time on getting opinions right

  [We’ll cover some of their techniques next time]

- But, polling is an increasingly challenging business

  Basically no one answers a phone poll

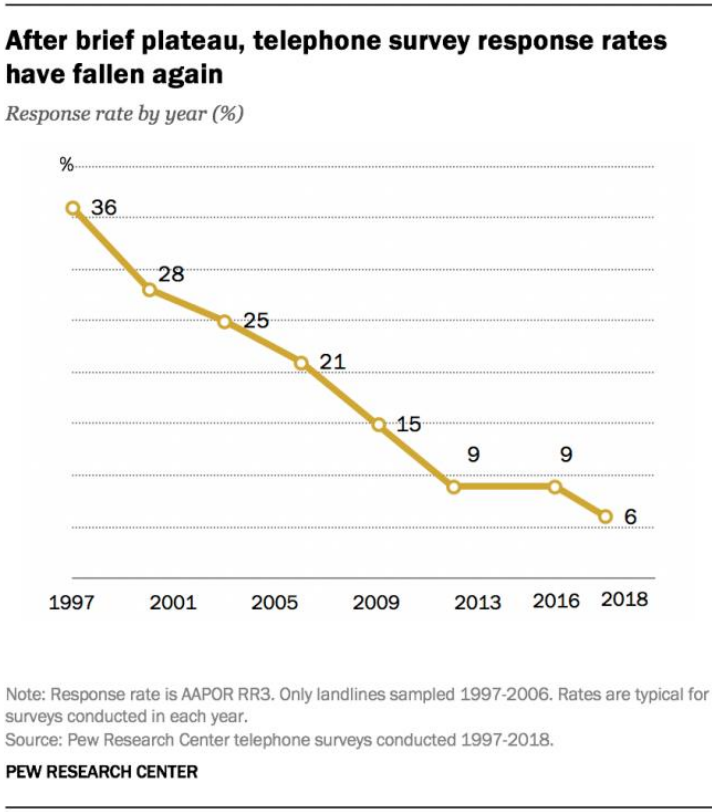
  Modeling opinions/turnout in diverse democracy is hard

  “social desirability” → “shy Trump voters” (?)

- In 2016, turns out that less educated voters both:

  Were less likely to answer polls

  Were more likely to vote Trump



After brief plateau, telephone survey response rates have fallen again

Response rate by year (%)

Note: Response rate is AAPOR RR3. Only landlines sampled 1997-2006. Rates are typical for surveys conducted in each year.
Source: Pew Research Center telephone surveys conducted 1997-2018.

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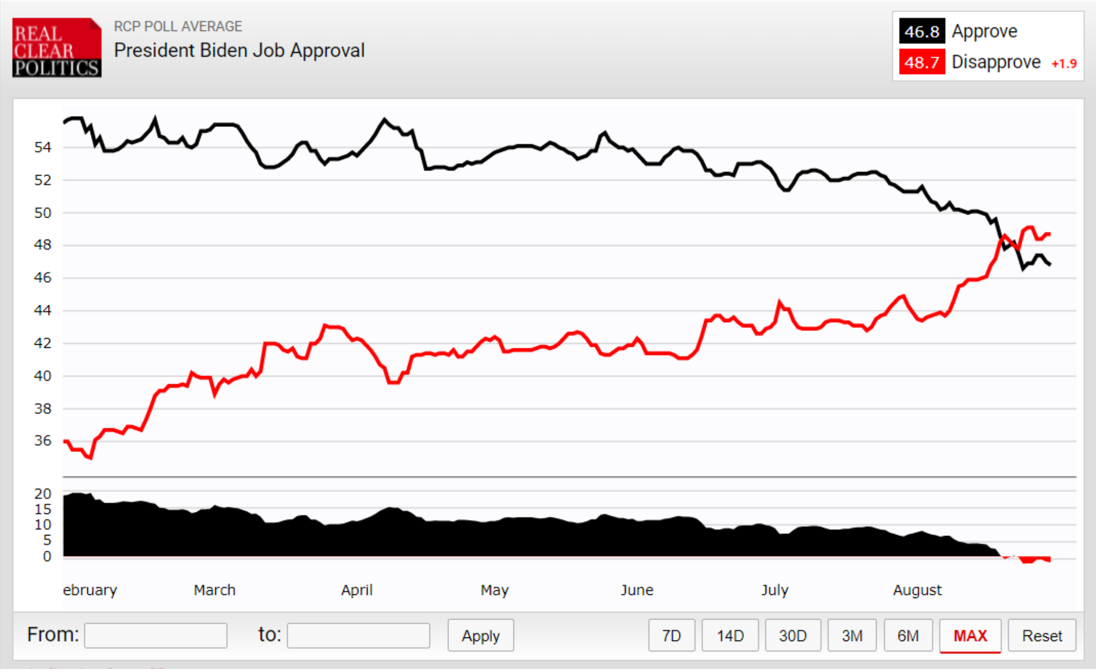
Differential non-response is everything

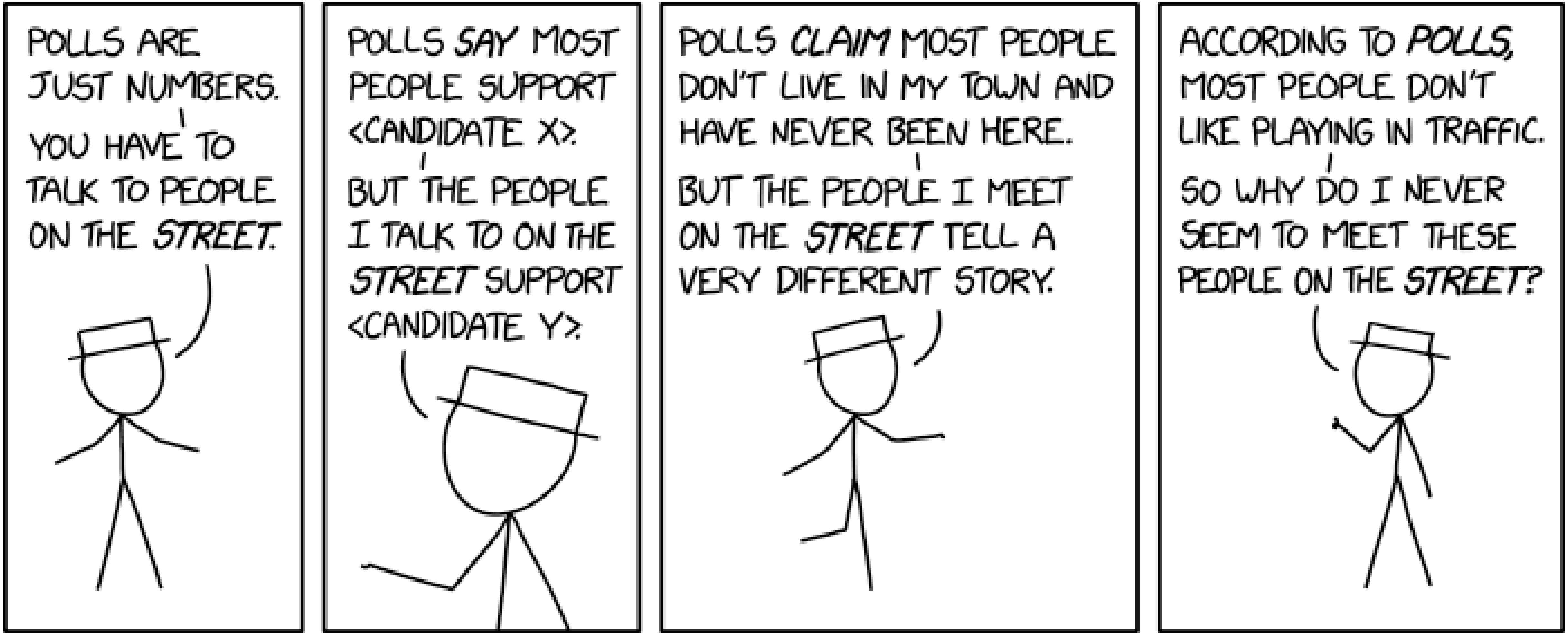
- Differential non-response shows up everywhere you're gathering opinions
- Your training data for whatever model you train faces the same issue!
- Standard "margin of error" calculations do not take this into account
- Differential non-response *over time* often explains "swings" in polls!



Parting thoughts

Be purposeful! Does your numeric data capture what you want it to?

Be skeptical! Just because a poll was “random” doesn’t make it good


POLLS ARE JUST NUMBERS. YOU HAVE TO TALK TO PEOPLE ON THE *STREET*.
POLLS *SAY* MOST PEOPLE SUPPORT <CANDIDATE X>. BUT THE PEOPLE I TALK TO ON THE *STREET* SUPPORT <CANDIDATE Y>.
POLLS *CLAIM* MOST PEOPLE DON'T LIVE IN MY TOWN AND HAVE NEVER BEEN HERE. BUT THE PEOPLE I MEET ON THE *STREET* TELL A VERY DIFFERENT STORY.
ACCORDING TO *POLLS*, MOST PEOPLE DON'T LIKE PLAYING IN TRAFFIC. SO WHY DO I NEVER SEEM TO MEET THESE PEOPLE ON THE *STREET*?

Other pollsters complain about declining response rates, but our poll showed that 96% of respondents would be 'somewhat likely' or 'very likely' to agree to answer a series of questions for a survey.

xkcd: Polls vs the Street

Questions?