01 Origins of Data

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Data Analysis 1 – MS Business Analytics: Exploration

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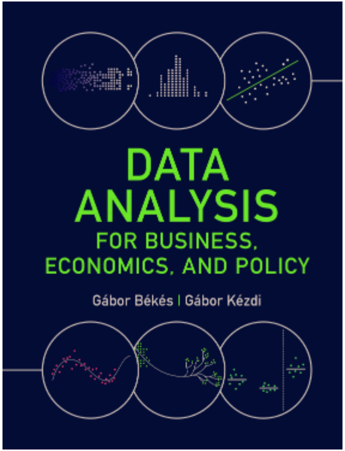
Slideshow for the Békés-Kézdi Data Analysis textbook


DATA ANALYSIS
FOR BUSINESS, ECONOMICS, AND POLICY
Gábor Békés | Gábor Kézdi

- Cambridge University Press, 2021
- gabors-data-analysis.com
  - Download all data and code: gabors-data-analysis.com/data-and-code/
- This slideshow is for Chapter 01

Motivation

- *Suppose, you want to understand the extent and patterns of differences in online and offline prices. A super project, the Billion Prices Project at MIT did a variety of data collection approaches such as crowd-sourcing platforms, mobile phone apps and web scraping methods.*
- *Interested in understanding more about management practices? The World Management Survey is a major effort by academics to survey practices around the world - asking the same questions in many countries the same way.*

What is data

- Data is most straightforward to analyze if it forms a single data table.
- Format: Data table (matrix)
- A data table consists of *observations* and *variables*.
  - Observations are also known as cases, or rows
  - Variables are sometimes called features or covariates.
- In a data table the rows are the observations, columns are variables.
- Storage: comma separated values .csv (.txt) is simplest. Delimited can be anything: comma(,), semicolon (;) or other (|)
- A dataset is a collection of data tables, typically related / used in a project
  - 10 data tables, same topic for 10 different years

Basics: data structure and quality

Data structures

- Cross-sectional (xsec) data have information on many units observed at the same time.
- Time series (tseries) data have information on a single unit observed many times.
- Multi-dimensional (panel) data have multiple dimensions.
  - Many cross-sectional units observed many times
  - Units observed in different space

Data structures

A bit more on multi-dimensional - panel (xt) data

- A common type of panel data has many units, each observed multiple times. Such data is sometimes called *longitudinal data*, or cross-section-time-series data, sometimes abbreviated as *xt data*.
- Example: countries observed repeatedly for several years
- In xt data tables observations are identified by two ID variables: one for the cross-sectional units, one for time.
- xt data is *balanced* if all cross-sectional units are observed at the very same time periods. It is called unbalanced if some cross-sectional units are observed more times than others.

Finding a good deal among hotels: data collection

- Welcome to Vienna, Austria
- `hotels` dataset
- Collected from a price comparison website + anonymized.
- Vienna, 2017 November weekday, $N = 428$
- For each hotel the data includes information on the location of the hotel, the price on the night in focus in EUR, average customer rating, stars of the hotel, and distance to the city center.

Image: en.wikipedia.org/wiki/File:Montage_of_Vienna.jpg

Data structures

Table: List of observations

hotel_id	accom_type	country	city	city_actual	dist	stars	rating	price
21894	Apartment	Austria	Vienna	Vienna	2.7	4	4.4	81
21897	Hotel	Austria	Vienna	Vienna	1.7	4	3.9	81
21901	Hotel	Austria	Vienna	Vienna	1.4	4	3.7	85
21902	Hotel	Austria	Vienna	Vienna	1.7	3	4	83
21903	Hotel	Austria	Vienna	Vienna	1.2	4	3.9	82

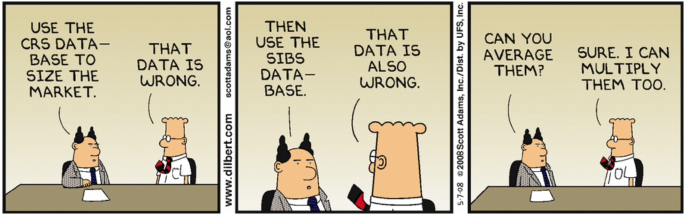
Source: `hotels` dataset. Vienna, for a 2017 November weekday

List of five observations with key variable values:

- ‘accom_type’ is the type of accommodation.
- ‘city’ is the city based on the search, city_actual is the municipality.

Data quality is key

- Data quality is key
- Garbage-in-garbage-out: If our data is useless to answer our question the results of our analysis are bound to be useless...
- ... no matter how fancy method we apply to it.


USE THE CRS DATA-BASE TO SIZE THE MARKET.
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CAN YOU AVERAGE THEM?
SURE. I CAN MULTIPLY THEM TOO.

Data quality and your question

Data quality is generally a subjective notion!

- First you have to specify what is your (research) question!
- What do you want to explore or understand?
- If you have a clear answer, then you can decide on your data quality!

However, there are some objective measures to decide if you have your question!

Data quality

1. Content - what is the substance a variable captures.
   - Just because a variable is called something it doesn't necessarily measure that (e.g., "product quality", "socio-economic status").
2. Validity - how close the actual content of the variable to the intended content.
3. Reliability. If we were to measure the same variable multiple times for the same observation it should give the same result.
4. Comparability of measurement - how similarly the same variable is measured across different observations.
5. Coverage -what proportion of the observations in focus are in the data.
   - Complete coverage (rare).
   - Incomplete coverage (almost always).
6. Unbiased selection - if coverage incomplete the observations that are included in the data should be similar to all observations that were intended to be covered.

SIDENOTE

- This is not the type of class where you will have to memorize a list
- But you should be able to evaluate the quality of the data you work with

- Always know your data.
  - Data quality is key (remember: garbage in, garbage out).
  - Data quality is determined by how the data was collected.

Data analysts should know their data

. Data analysts should know their data

- How data was born
- All details of measurement that may be relevant for their analysis

To this end, consider having

- README.txt that describes where dataset comes from
- VARIABLES.xls that provides basic information on your variables

Data collection

Data collection

- Automated data collection
- Survey
- Administrative / Census
- Big Data

Collecting data from existing sources

- Data, or information that can be turned into data, is collected by someone else
- For purposes different from the purpose of our analysis
- Data quality consequences
    - May not contain variables that we need
    - Validity of main variables may be high or low
    - Potential selection bias if incomplete coverage of observations
- Frequent advantages
    - Inexpensive
    - Often many observations
    - Can have complete coverage

Data collection: Digital

Automated data collection

- Application Programming Interface, or API – directly load data into a statistical software.
  - API is a software intermediary, or an interface,
  - It allows programs, or scripts, to talk to each other.
- API widely used in many context.
  - Macro data: FRED - St Louis Fed at `research.stlouisfed.org/docs/api/fred/`, also World Bank, etc.
  - Micro data such as weather at: `openweathermap.org/api`
- Data collection limited to dataset.
- Typically additional info available.

Data collection: Digital

- Collecting data from online platform
- html code includes data, can be found, analyzed and collected
    - online services
    - code in R (rvest) / Python (beautiful soup), Selenium (many languages)
- Need extensive cleaning
- Once a procedure is ready (code, script), can be repeated
- Data collection limited to what is on a site

Data collection: Administrative

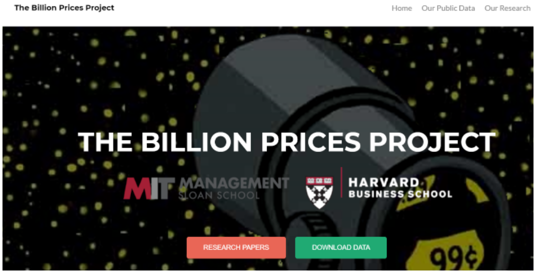
- Business transactions
- Government records, taxes, social security
- Often: census - records on the population
- Many advantages
  - Often great coverage, few missing values, high quality content
  - Many well defined and documented variables
- Some disadvantages
  - Variables defined for business/government purposes. May not fit in analysis plans
  - Often not detailed/specific enough
  - Biggest problem is very limited access

Finding a good deal among hotels: data collection

- The dataset on hotels in Vienna was collected from a price comparison website, by web scraping.
- On a specific date
- The purpose of the website is not facilitating data analysis...
- No other potential source
- Good quality, but noise, needed work to make it ready for analysis.
- Coverage is good but not full. Hotels advertising on these websites are not a random sub-sample. Which are the hotels that are left out?

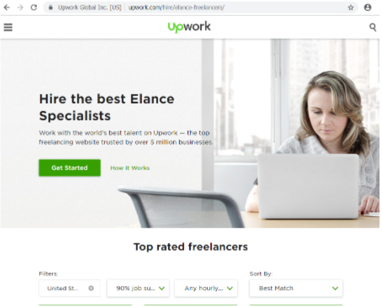
Comparing online and offline prices: data collection

- The Billion Prices Project - academic initiative - product prices collected
- This course: Cavallo (2017, AER)
- 56 large multi-channel retailers in 10 countries.
- price levels identical about 72 percent of the time.
- Price changes are not synchronized but have similar frequencies and average sizes.



Comparing online and offline prices: data collection

- BPP is about measuring prices for the same products sold through different channels
- Mixed methods
- Offline data collectors by Mechanical Turk / Upwork
- Online prices were scraped
- Project managers focusing on collecting info on exactly the same products on approximately during the same time



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Hire the best Elance Specialists

Work with the world's best talent on Upwork — the top freelancing website trusted by over 5 million businesses.

Top rated freelancers

Filters: United St... | 90% job su... | Any hourly...

Sort By: Best Match

Data quality - billion prices project data

1. Content - what product, what price
2. Validity - intention is price of target product available at store.
   What could go wrong?

Data quality - billion prices project data

1. Content - what product, what price
2. Validity - intention is price of target product available at store.
   What could go wrong?
3. Reliability. Timing is very difficult especially if price change frequently
4. Comparability in measurement- are products *equally* well identified? Laptop vs cheese
5. Coverage. Not universal. Project plan choice.
6. Unbiased selection. Time consuming planning. If electronic goods, need a typical set of TVs, phones etc.

Survey and sampling

Data collection: Survey

- Surveys collect data by asking people (*respondents*) and recording their answers.
- Answers to a *questionnaire* are short and easily transformed into variables.
- Major advantage: you can ask exactly what you want to know

- There are two major kinds of surveys: self-administered surveys and interviews.
- Web, telephone, in person, mix - computer aided interview.
- Choice of data collection approach matters a great deal.
- Self-administered survey
  - cheap and efficient, can use visual aids.
  - What could go wrong?

Sampling

- Sometimes we can collect data on all observations we want
- Those all observations are called the population
    - All employees in an organization
    - All countries on Earth
- More often we don't because it's impractical or prohibitively expensive
- Sampling is when we purposefully collect data on a subset of the population
    - A sample is a subset of the population
    - Sampling is the process that selects that subset

Representative sample

- A sample is good if it represents the population
- A sample is representative of a population if
  - all important variables have very similar distributions in the sample and the population
  - all patterns in the sample are very similar to the patterns in the population
- Examples
  - The age distribution of a sample of employees is the same as the age distribution of all employees
  - The average online - offline price difference is the same in the sample of stores in the sample as in all stores with both online and offline sales

How can we tell if a sample is representative

- Never for sure
  - We know the distributions and patterns in the sample but not in the population
  - The very reason to have a sample is because we can't collect the same data on all observations in the population
- Benchmarking
  - We may know a few distributions or patterns in the population
  - Those should be similar in the sample
  - Example: proportion female employees in the sample and among all employees
- Knowing the process of sampling
  - Random sampling is known to lead to representative samples with high likelihood

Sampling: Random sampling

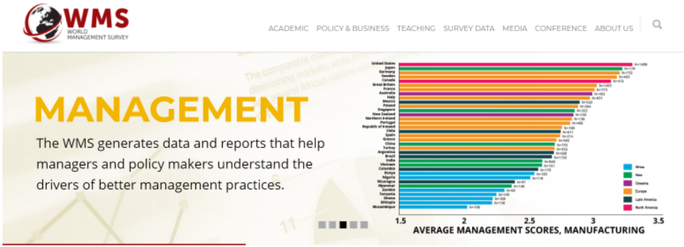
- *Random sampling* is a selection rule that is independent of any important variable
- Random sampling is the process that most likely leads to representative samples.
- Any other methods may lead to biased selection.
- Important is the independence of the rule from anything important for the analysis
- Examples
  - Good: people with odd-numbered birth dates (a 50% sample)
  - Good: the first half of a list of firms that were sorted by a random number generated by the computer
  - Bad: the first half of a list of people by alphabetical order
  - Bad: firms that were established in the most recent years.

Random sampling is best

- Provided sample is large enough.
- In small samples (dozens) anything is possible
- It's the sample size that matters not how large a fraction it is of the total population size.
- Sample of a few thousand observations may equally well represent populations of fifty thousand, ten million, or three hundred million.
- The required sample size depends on details of what you want to measure
- MORE on this is DA4 (Winter)

Management quality and firm size: data collection

- What causes superior performance of some countries? What causes superior performance of some firms in some countries?
- Many potential arguments: Institutions that lead to competitive markets. Education that helps research - yields new patents
- www.worldmanagementsurvey.org - Survey on firms and management.



MANAGEMENT

The WMS generates data and reports that help managers and policy makers understand the drivers of better management practices.

Management quality and firm size: data collection

- Ask 10K+ manufacturing firms (also public sector)
- Developing management questions
  - Scorecard for 18 monitoring, targets and incentives practices
  - Approx 45 minute phone interview of manufacturing plant managers
- Obtaining unbiased comparable responses ("Double-blind")
  - Interviewers do not know the company's performance
  - Managers are not informed (in advance) they are scored
  - Run from London, with same training and country rotation
- Getting firms to participate in the interview
  - Introduced as "Lean-manufacturing" interview, no financials
  - Run by 100+ MBAs (credible with business experience)

Management quality and firm size: data collection

Example question: "how is performance tracked?"

- (1): Measures tracked do not indicate directly if overall business objectives are being met. Certain processes are not tracked at all.
- (3): Most key performance indicators are tracked formally. Tracking is overseen by senior management.
- (5): Performance is continuously tracked and communicated, both formally and informally, to all staff using a range of visual management tools.

Management quality and firm size: data collection

- Survey quality assessment
- Content of each score - based on information gathered in a standardized way translated to scores by the interviewers using standardized rules.
- Validity, reliability and comparability - How to think about assessment?
- What would be an alternative? Pros and Cons?

What is different with Big Data?

- Big Data refers to: (i) massive (very large) datasets that are (ii) often automatically and continuously collected and stored, and (iii) may be of complex nature.

(i) Very large. Billions of observations. (Bigger than what fits into your computer.)

- Warning: just because sample is large, it is not necessarily representative!!!!

(ii) Automatic collection. Not for your analytic purpose - unlike a survey. Data collected by apps, sensors.

(iii) Complex - text (video, music/noise), network, multidimensional, maps

What is different and what is he same with Big Data?

Some of these are kind of cryptic for now; we will clarify them in subsequent chapters

- Different
  - A particular source of uncertainty of the results of an analysis is greatly reduced
  - Rare or more nuanced patterns can be uncovered
  - Practical challenges
    - Some challenges may be solved by working with a random subsample
- Same
  - Need to represent entire population if incomplete coverage
    - Example: Big Data with 75% coverage with a selection bias leads to biased results
    - Non-big data from same population with 1% random sample leads to good results

Sample selection bias

- The sample you collect is different to the population
- This difference is crucial in the story
- Example: Predicting presidential election
  - 1936: Literary Digest. FD Roosevelt vs Landon. 10m people asked. 2m replied. Biggest poll ever. Landon was predicted win 57%
  - 1948 Chicago Tribune. Dewey predicted beat Truman. Used phone registry.
  - What could have gone wrong?

Legal and ethical aspects

- Data collection - ethical and legal constraints
- Especially with sensitive information
- GDPR

Always communicate with the source owner(s) and or with legal professional if you are planning to use seemingly sensitive data!

Data collection: hard, time-consuming, costly.

- Collecting data is a tedious task, and costly as well.
- Usually it is much harder than expected, with many on-the-field problems.
- Worth getting some experience!

AI and data collection, wrangling

- Data collection and management often behind walls
- AI can help write code to web-scrape etc
- AI is great to give a first impression of your dataset, incl. quality, data structure
- AI is helpful to discuss sampling ideas
- AI needs context to do good, and will not have proper domain knowledge
- AI needs supervision

Main takeaway

- Know your data
  - How it was born,
  - What its main advantages are;
  - What its main disadvantages are.
- Data quality determines the results of your analysis
  - Data quality is determined by how the data was born.
- Data is stored in data tables
  - Rows are observations
  - Columns are variables
- Data may come from
  - Existing sources (admin, transactions, web scraping)
  - Collected purposefully for the analysis (surveys)