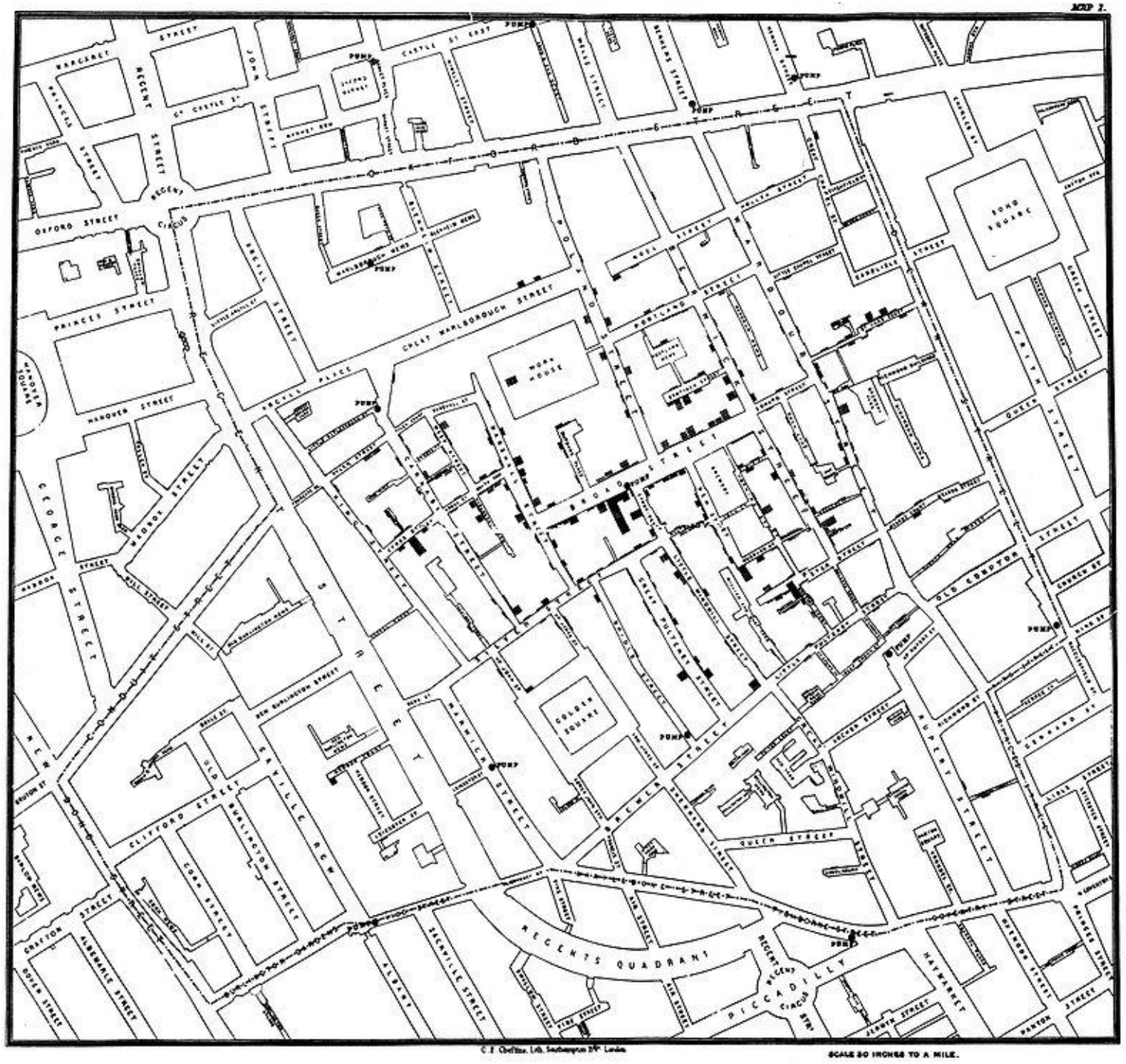
DATA VISUALIZATION AND DATA EXPLORATION

"Discovery is no longer limited by the collection and processing of data, but rather management, analysis, and visualization."

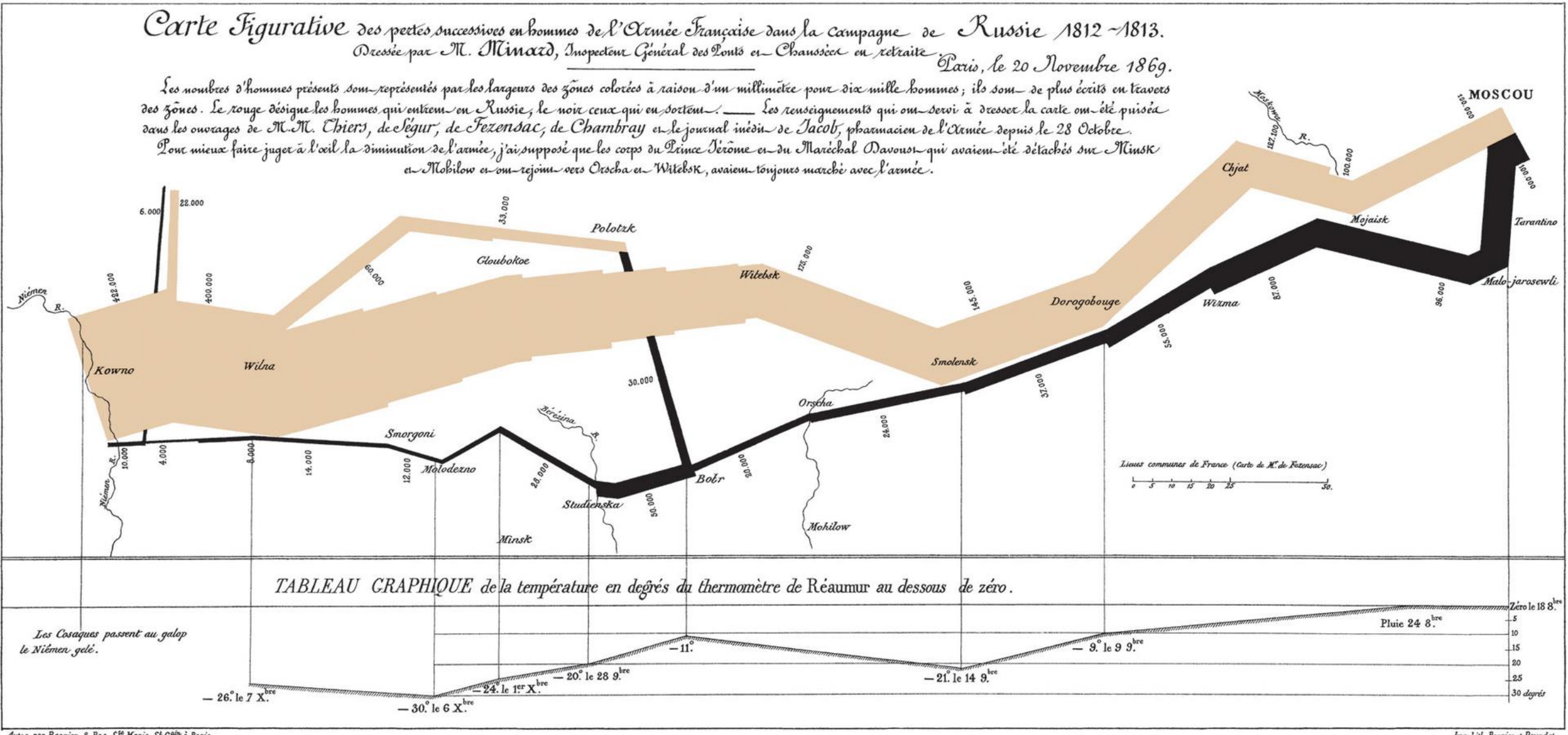
@DamianMingle

London's Cholera Outbreak of 1854

Physician John Snow links the outbreak to a contaminated well by plotting number of cases on a map, jump-starting the science of epidemiology.

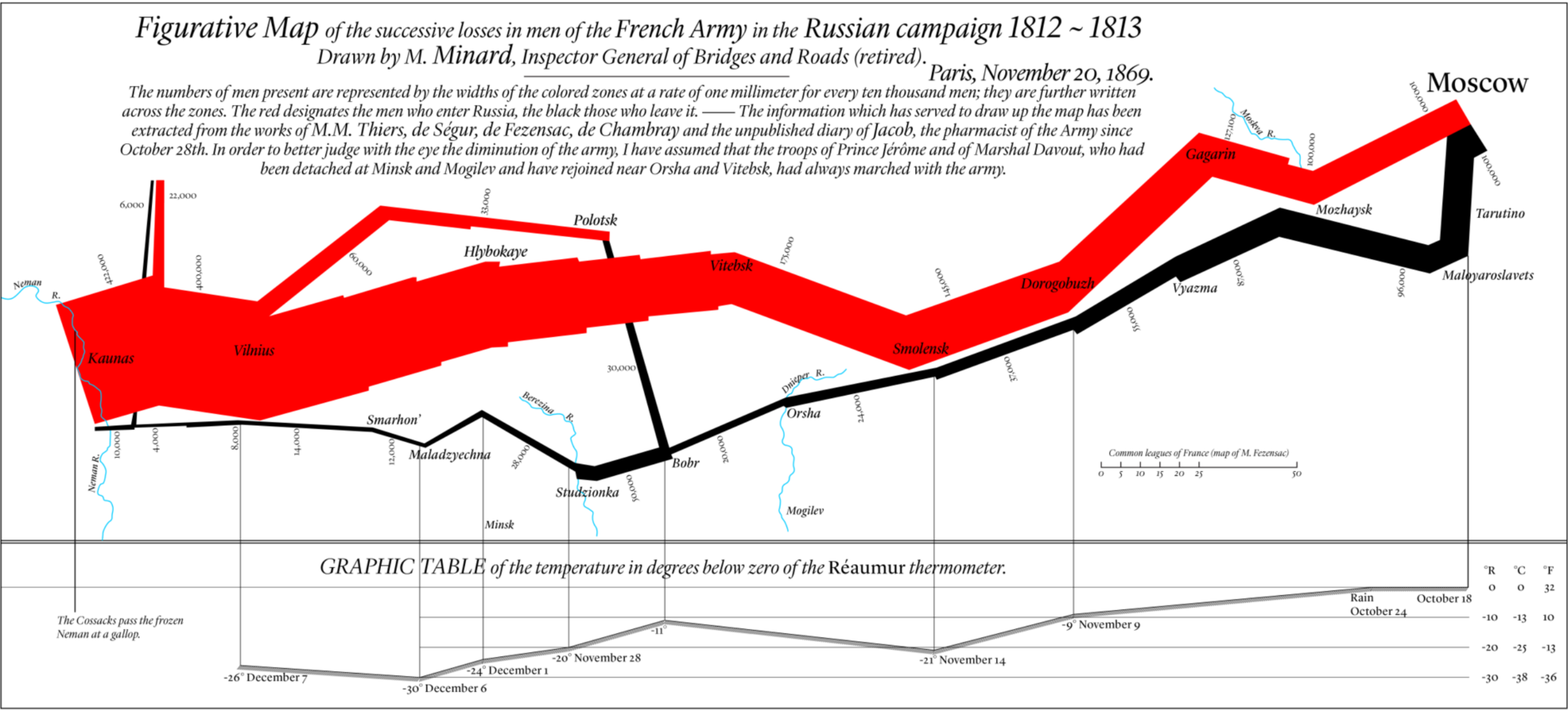


[Minard, 1869]



Minard's March to Moscow

[DAL Podcast #3 – https://youtu.be/tS_2_lQ5gRw]



Minard's March to Moscow

[J.P. Blackard]

INFOGRAPHICS

Created for **story-telling** purposes (**subjective**)

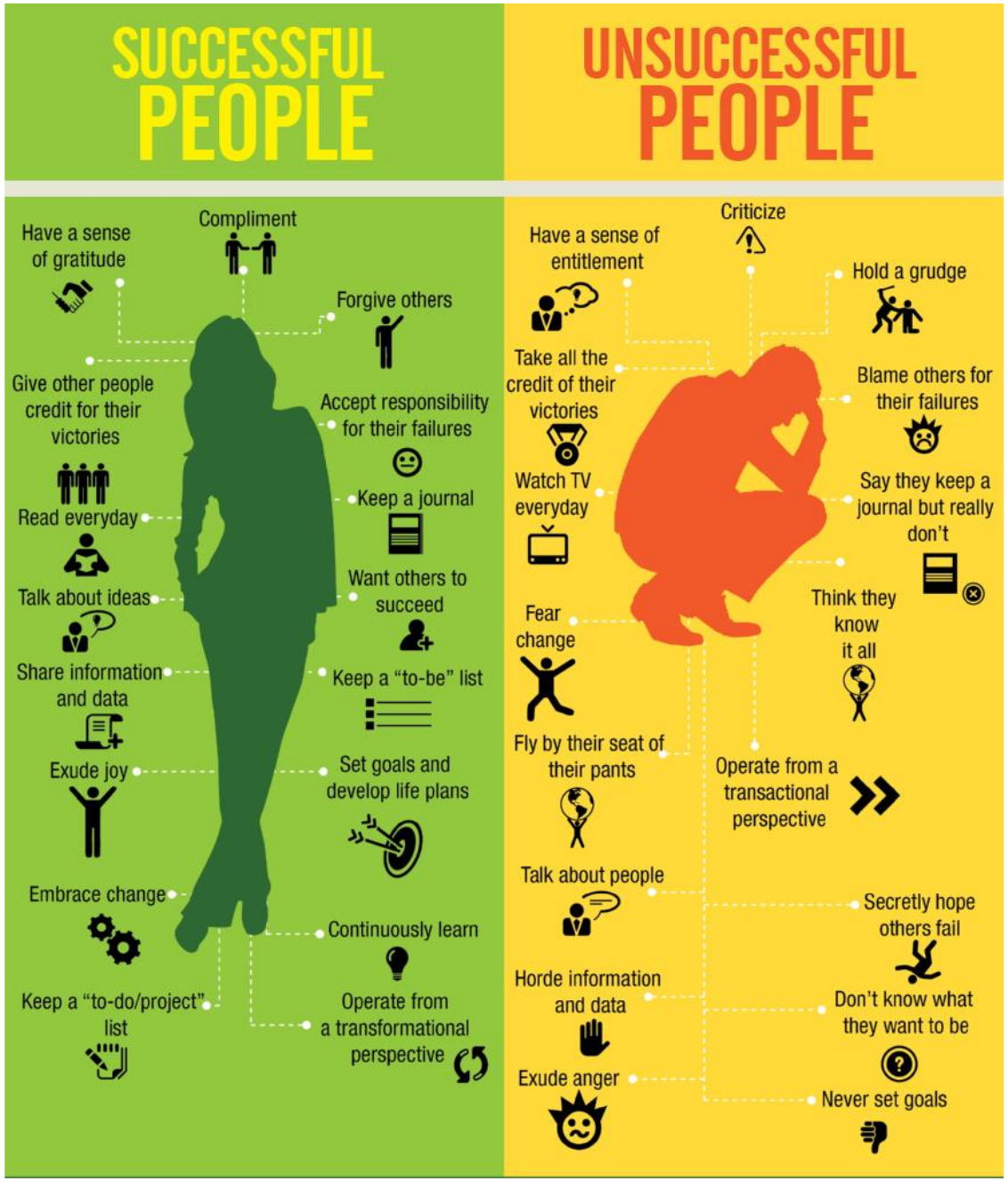
Intended for a **specific** audience

Self-contained and discrete

Graphic design aspect is key

Cannot usually be re-used with other data

Can incorporate **unquantifiable** information



IDLEWYLD Sysabee DAVHILL

[Author unknown]

DATA VISUALIZATION

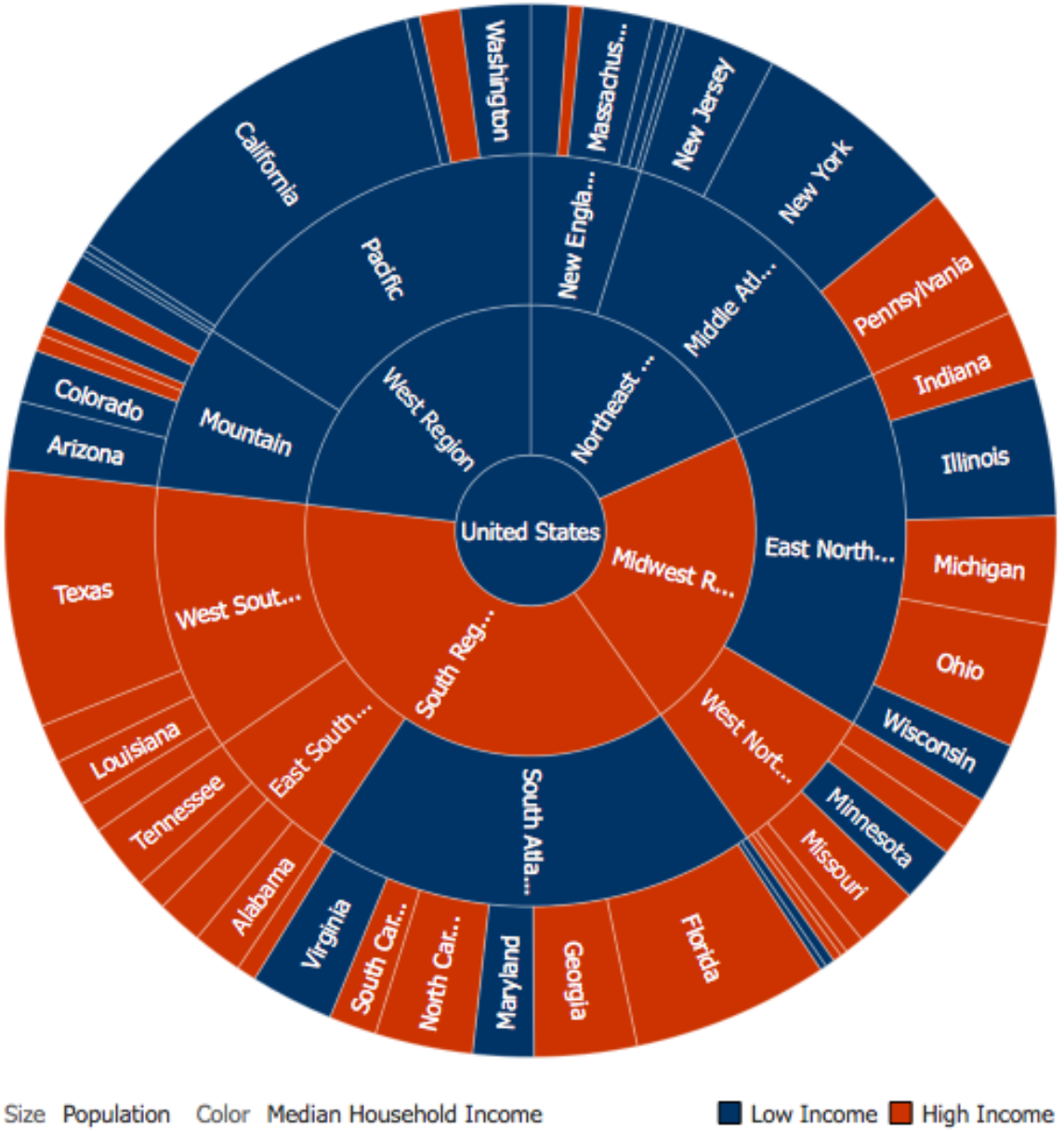
A **method**, as well as an item (**objective**)

Typically focuses on the **quantifiable**

Used to make sense of the data or to make it **accessible** (datasets can be massive and unwieldy)

May be generated automatically

The look and feel are less important than the **insights conveyed** by the data



DATA UP TO THE 20TH CENTURY

In the 20th century, data problems were mostly related to

- **engineering** (design of machines)
- **sciences** (formulation of theories)

Problems were solved **empirically**, **theoretically**, or through **computation**.

DATA UP TO THE 20TH CENTURY

Engineers equipped machines with sensors ⇒ used data to assess if the machines behaved as expected & to improve designs.

Scientists set up experiments ⇒ used data to test the validity of theories.

- Experiments are expensive; relatively few data points are generated.

Data contained additional information which is often ignored.

- Example: Mendel's experimental data, analyzed by Fisher, found to be too good to be true.

DATA IN THE 21ST CENTURY

In the 21st century, there is:

- there is **more data**
- it's mostly **digital**
- it's mostly **observed** (rather than generated by designed experiment)

Problems are solved **empirically**, **theoretically**, through **computation** and/or **data exploration/visualization**.

DATA IN THE 21ST CENTURY

Empirically: observe and describe what happens

Theoretically: generalize and build models and generalizations to understand what happens

Computationally: design computer simulations to better understand what happens

Data Exploration/Visualization: the new approach to understanding

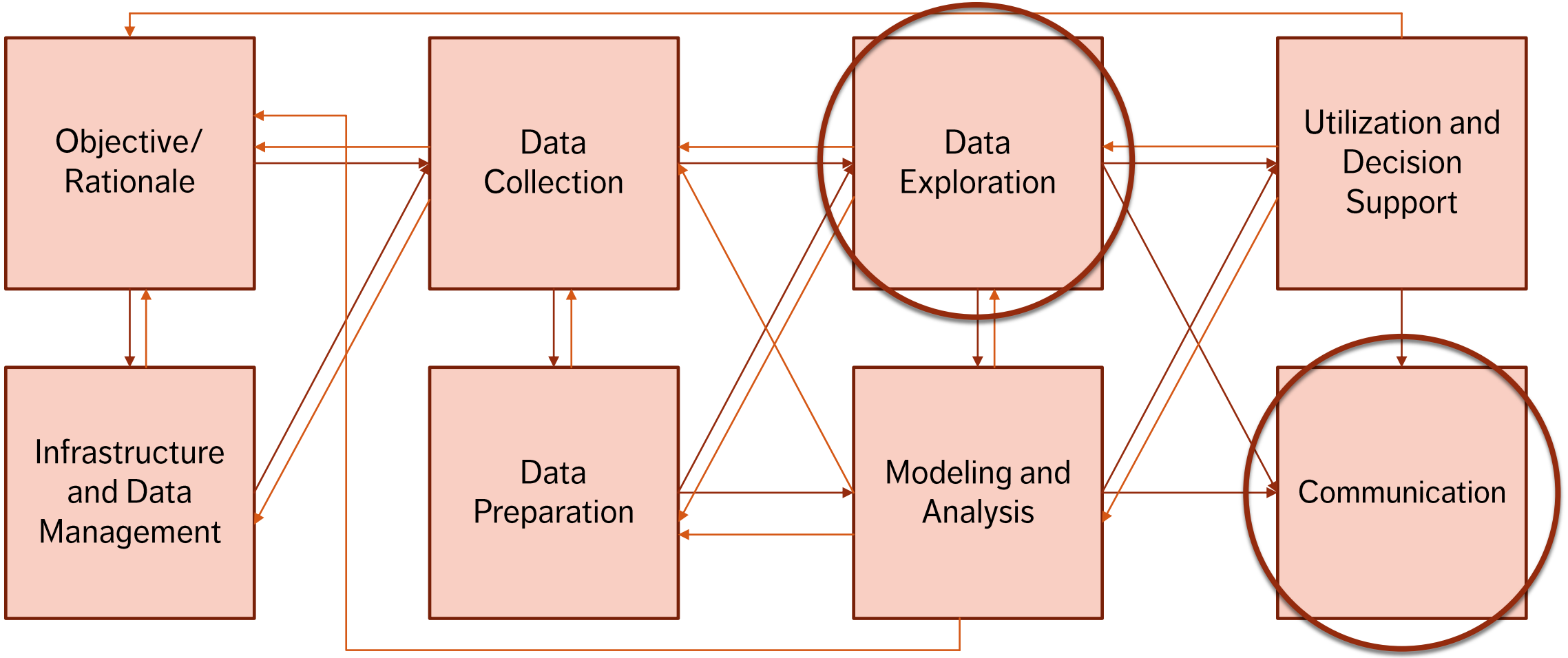
EXERCISE

In teams or individually, identify a few data visualizations that appeal to you (professionally, esthetically, or both).

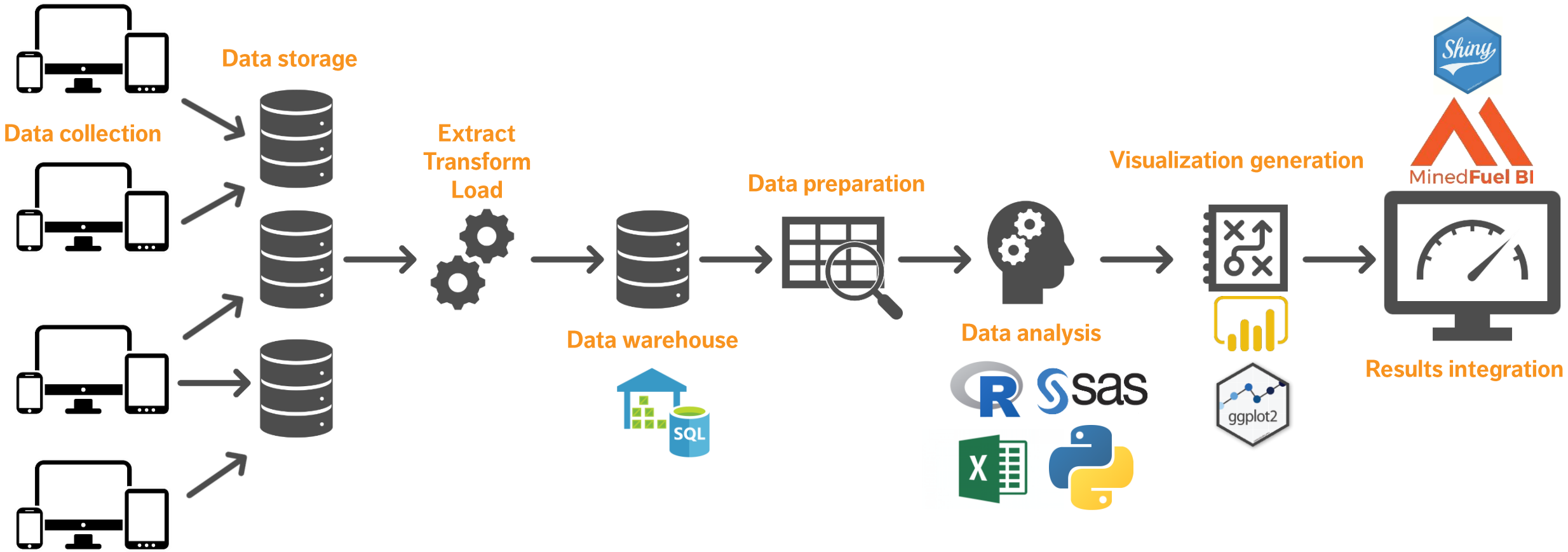
What is the story being told by the visualization?

What kind of data is needed to build these visualizations?

THE (MESSY) ANALYSIS PROCESS



DATA ENVIRONMENT



Visualizations account for only ~10% of the process.

EXERCISE

In teams or individually, identify work scenarios for which data visualization could prove useful.

What insight could be drawn from such visualizations?

Would such visualizations get a buy-in from your supervisors/employers?

How much work would be required to get from design to completion? Are the obstacles mostly of a technical nature? Related to data procurement?

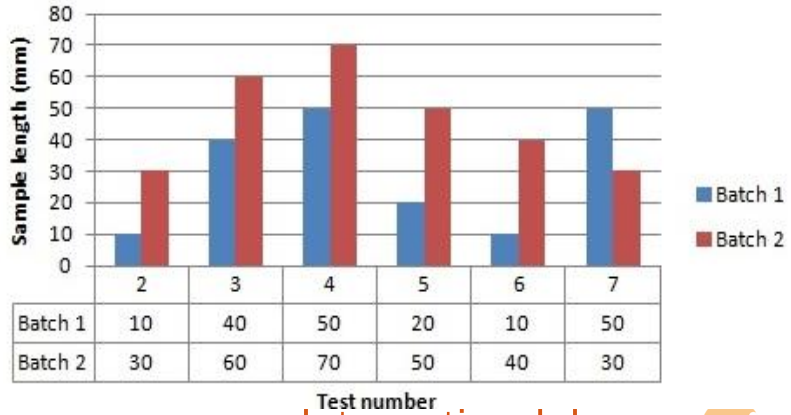
OVERVIEW

The past is **data-driven:**

- mostly Excel (or reporting tools like Cognos)
- mostly numbers, tables and non-interactive graphs
- distributed on desktop computers, by email, in PowerPoint presentation
- static, mostly backwards looking (lagging indicators)
- KPIs and dashboards were somewhat contrived

North Region Unit Sales by City

Region	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06
Actuals							
Seattle	111	653	1,598	3,411	3,972	5,092	5,2
Boise	26,779	27,867	29,153	30,557	33,402	35,400	35,4
Portland	33,078	34,401	37,535	39,916	41,357	45,306	46,6
Spokane	25,417	26,669	28,092	29,020	29,674	30,501	30,8
North Region	**199,841**	**211,053**	**226,789**	**242,957**	**256,605**	**273,640**	**277,7**
Plan							
Seattle	693	468	790	1,383	2,205	3,180	4,2
Boise	29,525	26,062	27,088	28,269	29,536	30,821	32,1
Portland	32,276	34,708	36,737	38,857	41,066	43,364	45,7
Spokane	30,500	26,644	27,987	29,430	30,994	32,594	34,2
North Region	**191,783**	**203,916**	**216,524**	**230,474**	**246,390**	**263,378**	**281,2**
Variance							
Seattle	-582	185	808	2,029	1,767	1,912	1,0
Boise	-2,746	1,805	2,064	2,288	3,866	4,578	3,2
Portland	802	-307	798	1,059	291	1,942	9
Spokane	-5,082	25	105	-410	-1,320	-2,093	-3,3



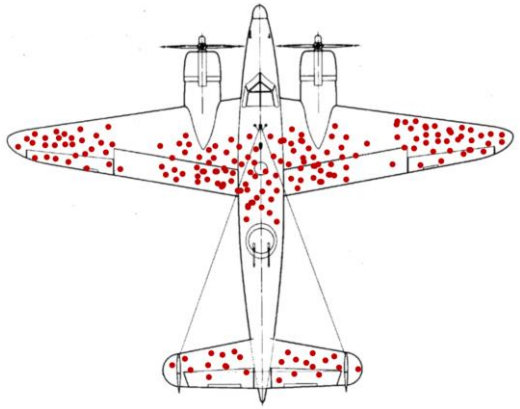
	2	3	4	5	6	7
Batch 1	10	40	50	20	10	50
Batch 2	30	60	70	50	40	30

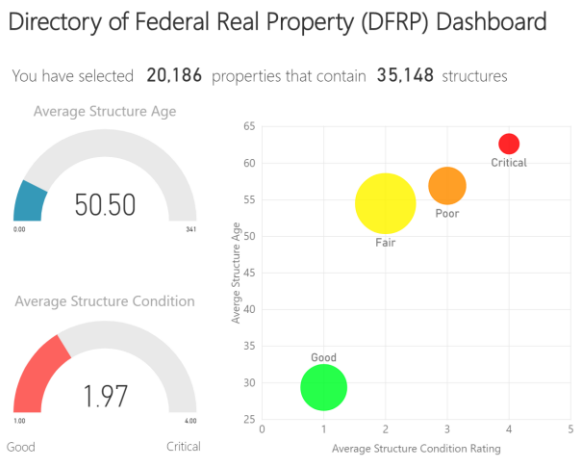
OVERVIEW

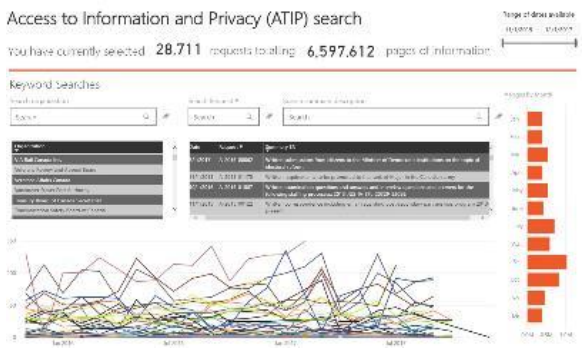
The future is **story-driven:**

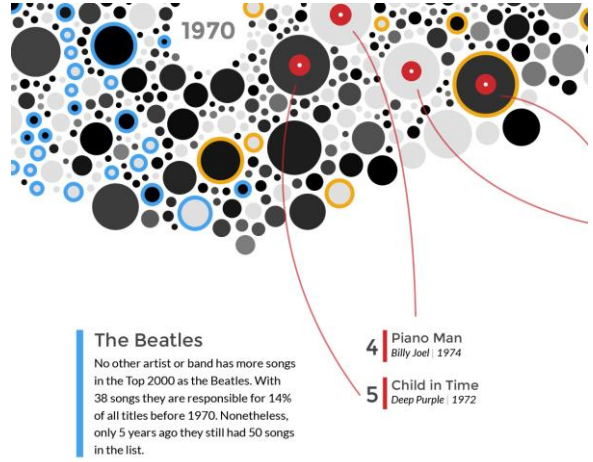
- new tools: Power BI, R, Qlickview etc.
- mostly visualizations, occasional numbers and tables
- distributed on the web (internal and external)
- dynamic and both backwards and forwards looking (leading and lagging indicators)
- data for everyone

DEFINING CONTEXT









Seconds | **Minutes** | **Fraction of Hour** | **Hours**

← **Infographics/Data Viz** →

← **Dashboards** →

← **Reports** →

← **Data Art** →

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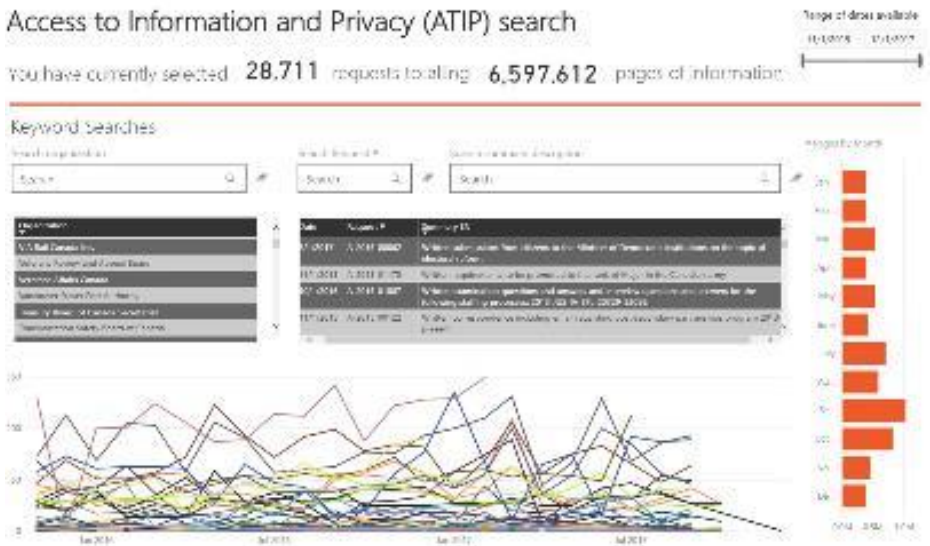
data-action-lab.com

EXPLORATORY VS. EXPLANATORY ANALYSIS

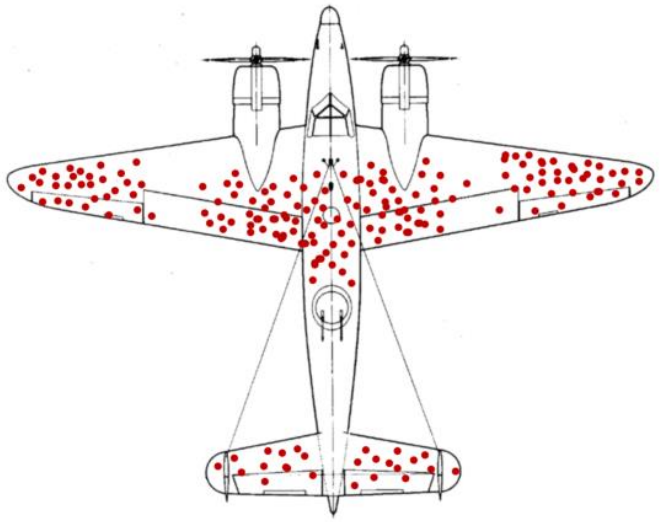
Exploratory: understanding the **DATA** (associated with reports)

Explanatory: communicating a **STORY** (associated with dashboards and data viz)



Exploratory

vs.



Explanatory

SOME BASIC QUESTIONS

What system does your data represent – objects, attributes, relationships?

How does it represent this system – i.e. the data model?

Who made this dataset? When? For what purpose?

Assuming a flat file – what do the rows represent? What do the columns represent?

Do you even have enough information (e.g. **metadata**) to answer these questions? Where can you find more information?

NON-VISUALIZATION BASED SUMMARIES OF YOUR DATASET

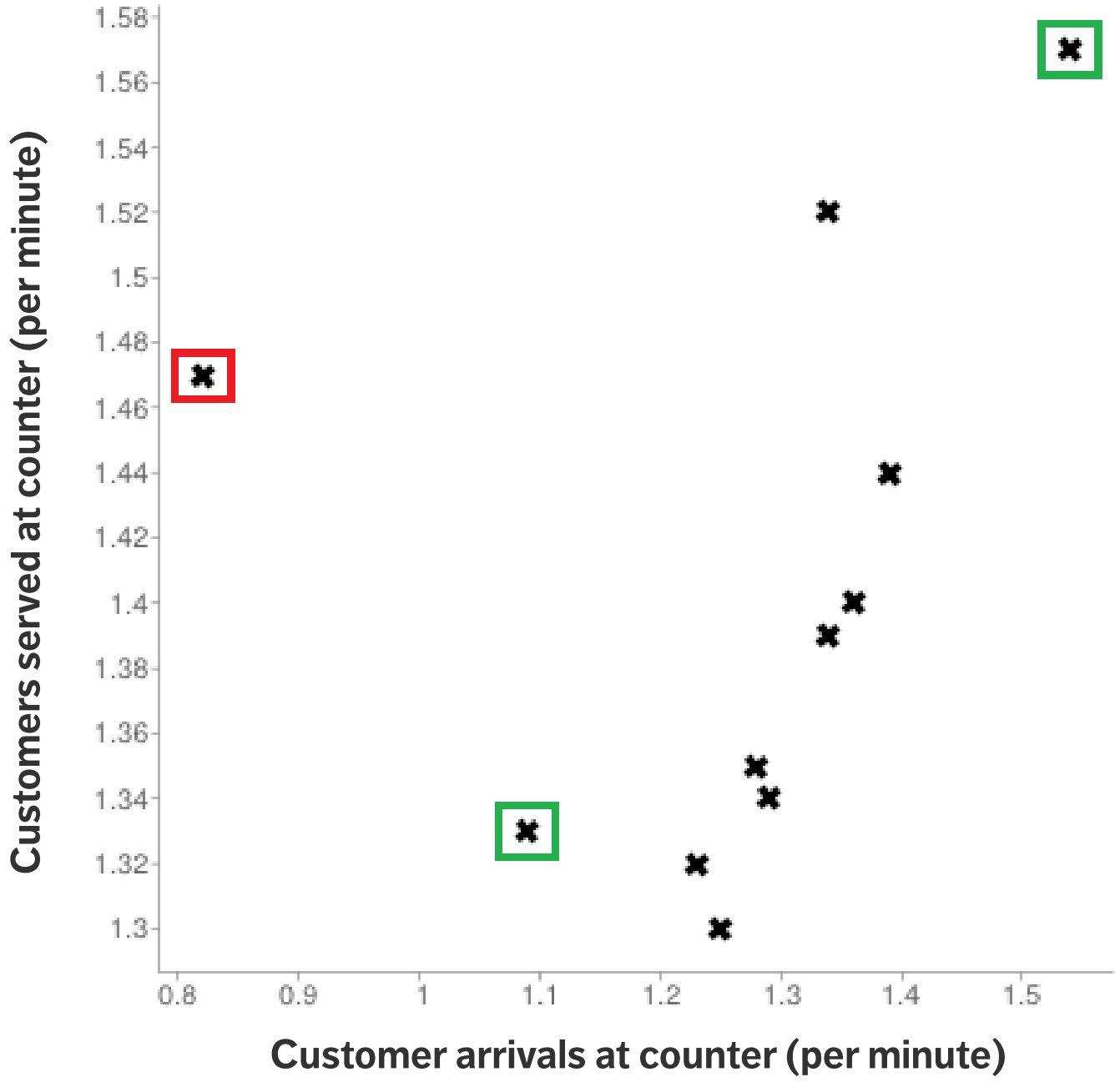
```
       Cl              NO3              NH4
 Min.   :  0.222   Min.   : 0.000   Min.   :    5.00
 1st Qu.: 10.994   1st Qu.: 1.147   1st Qu.:   37.86
 Median : 32.470   Median : 2.356   Median :  107.36
 Mean   : 42.517   Mean   : 3.121   Mean   :  471.73
 3rd Qu.: 57.750   3rd Qu.: 4.147   3rd Qu.:  244.90
 Max.   :391.500   Max.   :45.650   Max.   :24064.00
 NA's   :16        NA's   :2        NA's   :2

    season
 Length:340
 Class :character      autumn spring summer winter
 Mode  :character          80     84     86     90
```

PRE-ANALYSIS USE

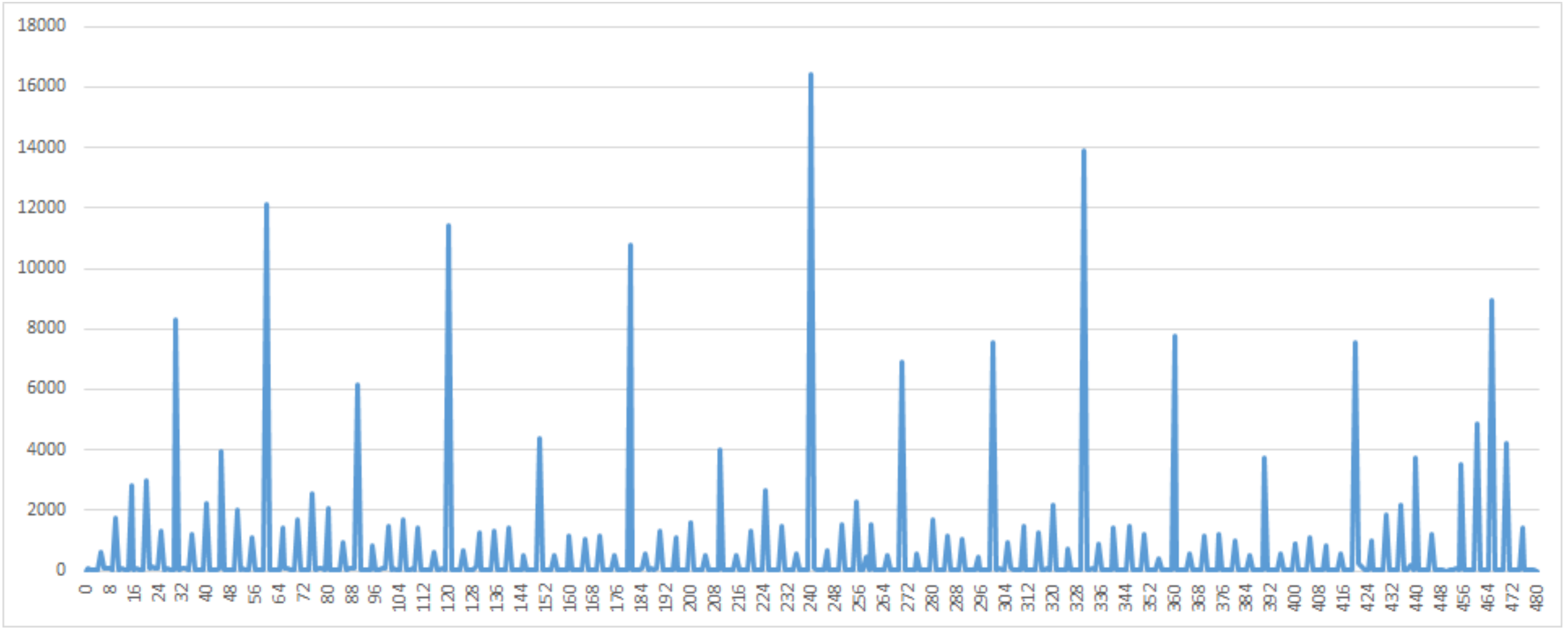
Data visualization can be used to set the stage for analysis:

- **detecting anomalous entries**
  invalid entries, missing values, outliers
- **shaping the data transformations**
  binning, standardization, Box-Cox transformations, PCA-like transformations
- **getting a sense for the data**
  data analysis as an art form, exploratory analysis
- **identifying hidden data structure**
  clustering, associations, patterns informing the next stage of analysis

[Personal dataset]

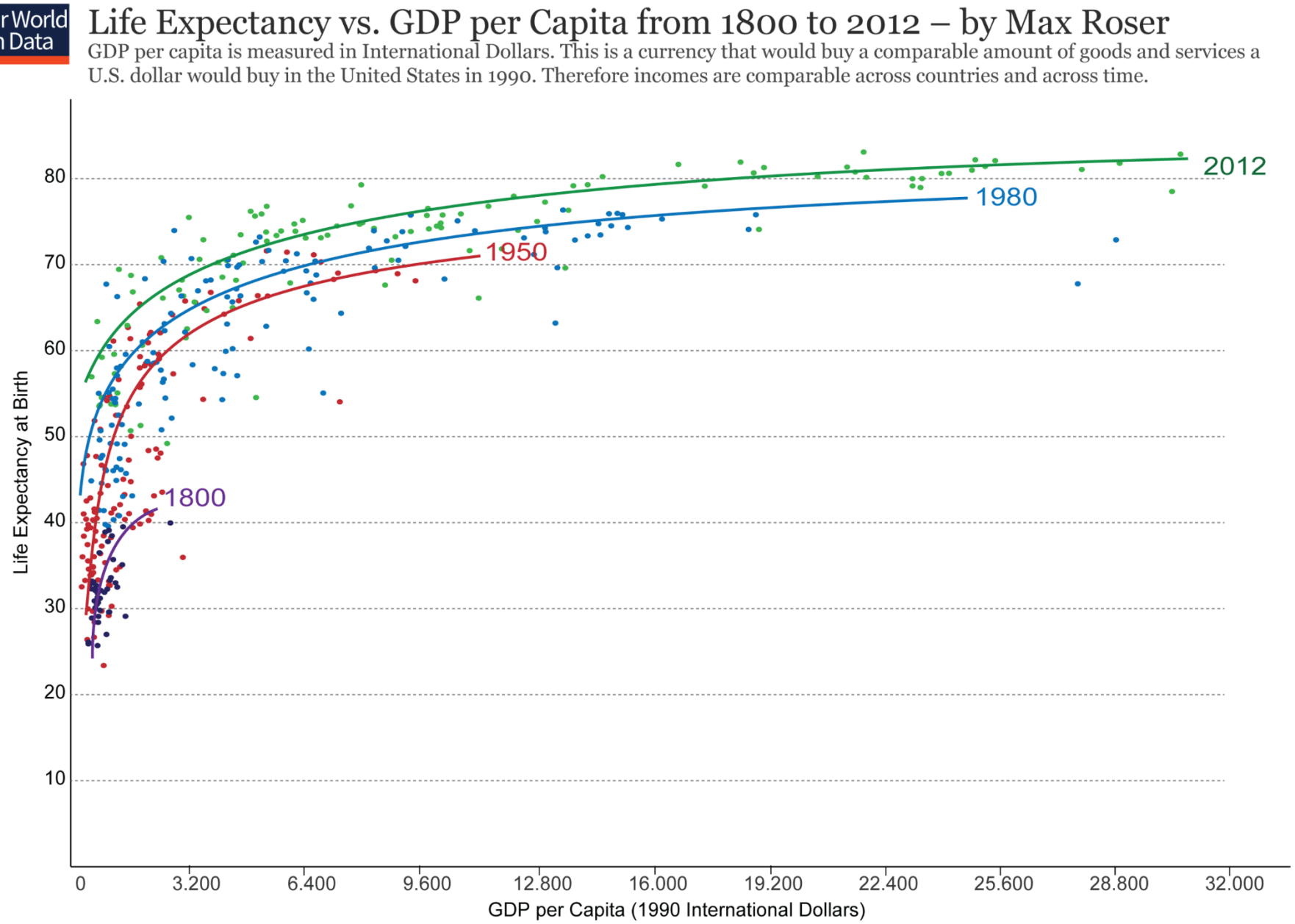


[Personal dataset]



Self-reported work hours (mins)

[https://ourworldindata.org/life-expectancy]



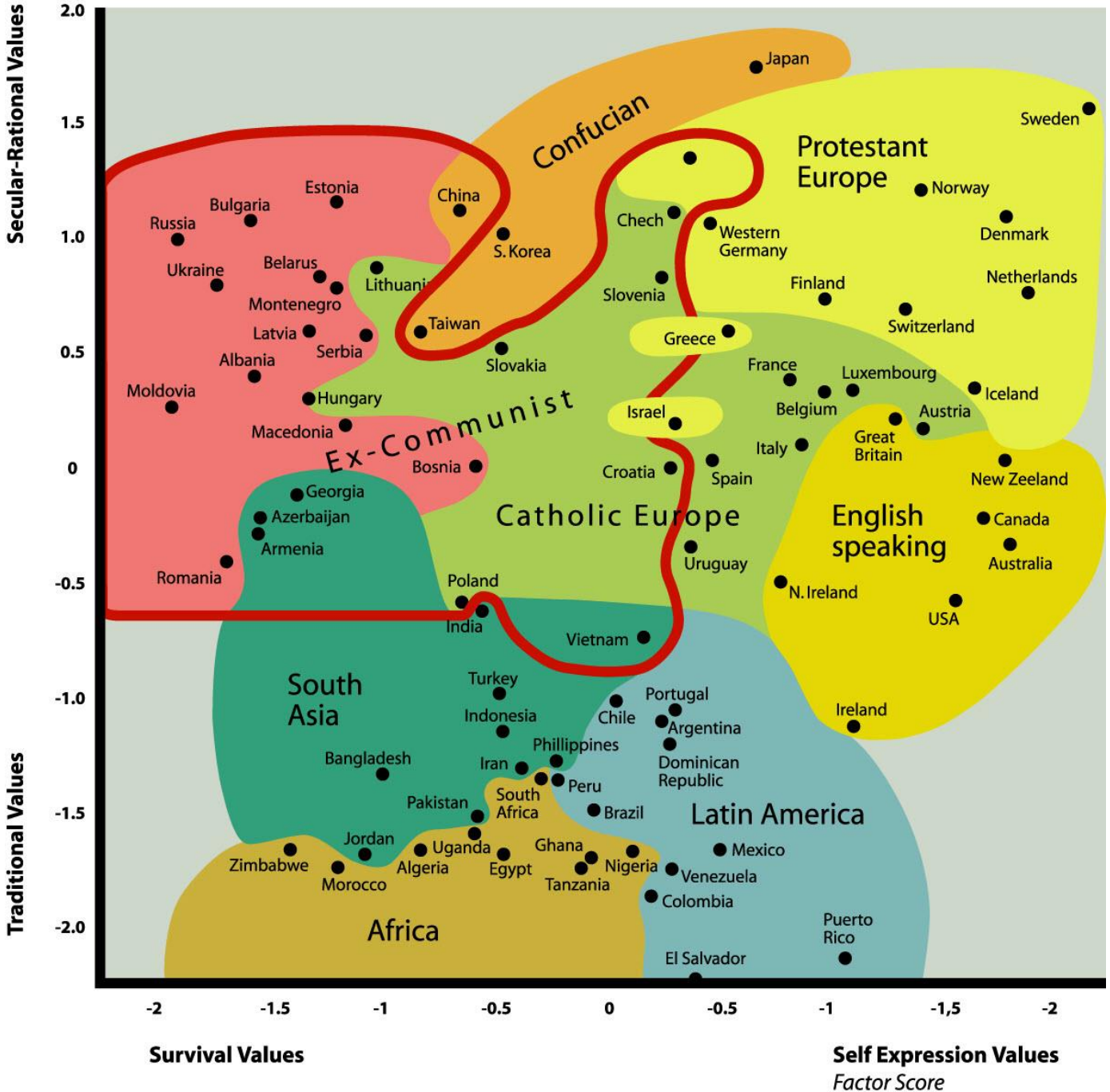
This graph displays the correlation between life expectancy and GDP per capita.

Countries with higher GDP have a higher life expectancy, in general.

The relationship seems to follow a logarithmic trend: the unit increase in life expectancy per unit increase in GDP decreases as GDP per capita increases.

Inglehart-Welzel's Global Cultural Map (2010-2014)

[https://en.wikipedia.org/wiki/World_Values_Survey]



Traditional values
importance of religion, parent-child ties, deference to authority and traditional family values.

Secular-rational values
less emphasis on religion, traditional family values and authority.

Survival values
emphasis on economic and physical security.

Self-expression values
high priority to environmental protection, growing tolerance of foreigners, gays and lesbians and gender equality

DISCUSSION

Which of the pre-analysis uses of visualization is most relevant to your work?