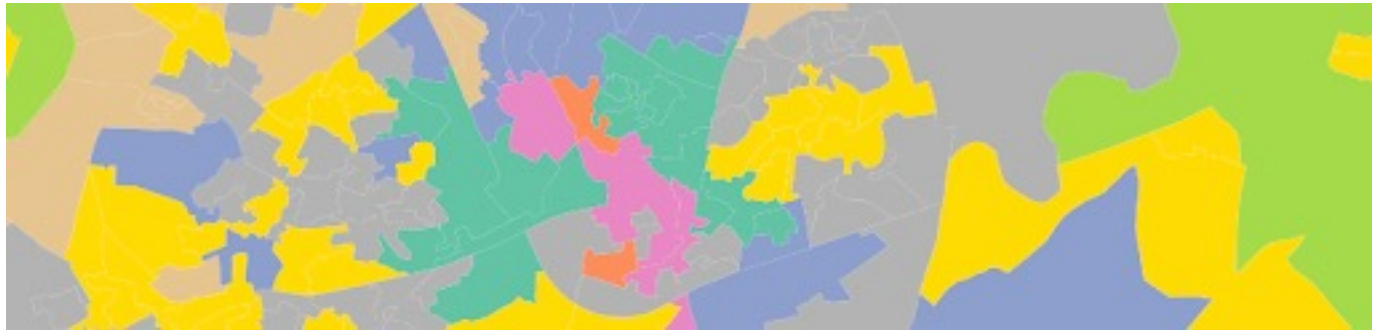
Principles of Spatial Analysis

WEEK 07: GEODEMOGRAPHICS



UCL

This week

- Geodemographic classifications
- k-means clustering

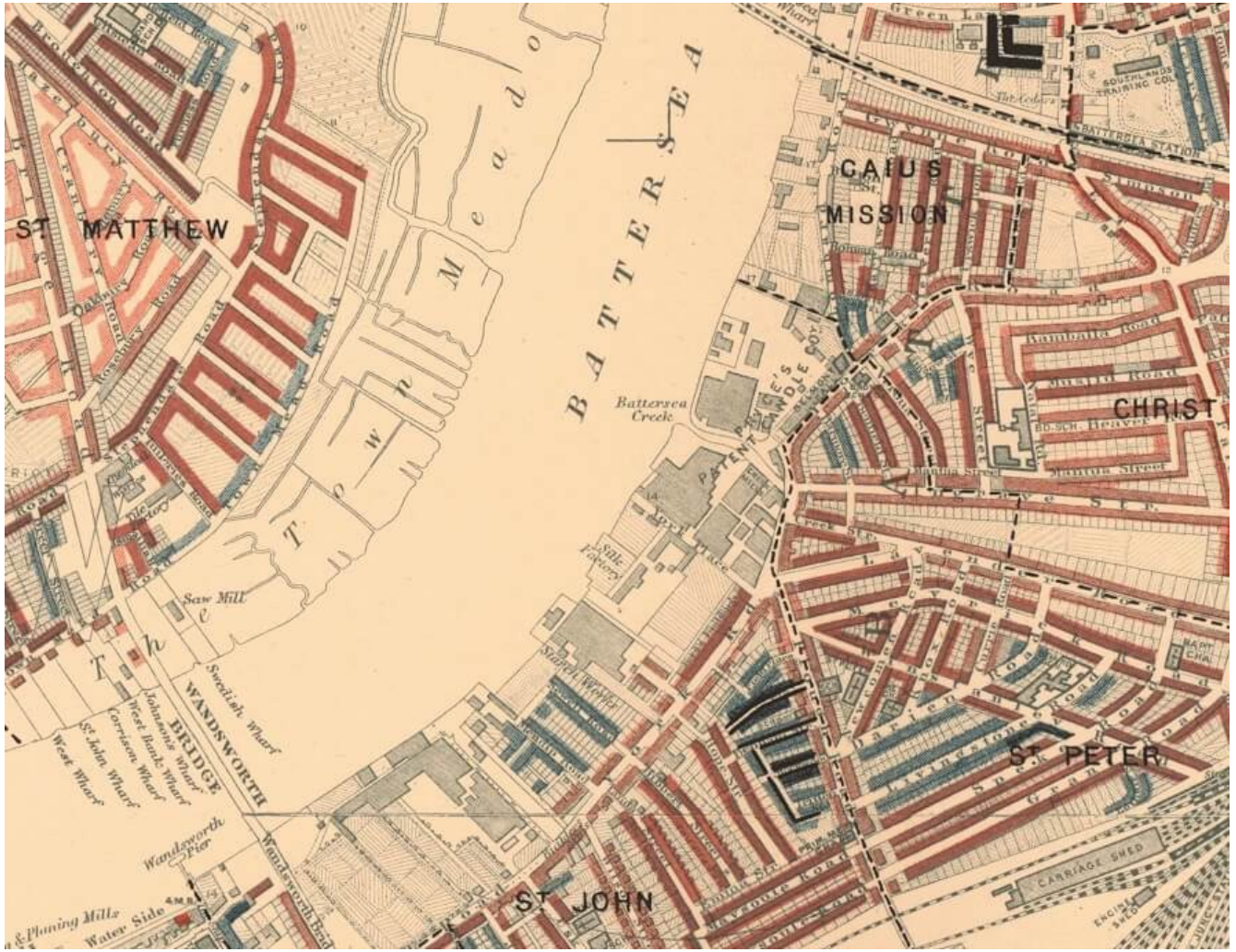
Geodemographics

- Analysis of people (*demographics*) by where they live (*geo*).
- Used to identify similar neighbourhoods or administrative areas.
- Means of multivariate data reduction for the differentiation of areas.
- Been around for many many years, dating back to the late 1800s.

Charles Booth

- Created the first geodemographic-style classification.
- Shipping business owner and philanthropist.
- Survey: *Life and Labour of People in London.*
- Mostly qualitative analysis by walking through areas.
- Books and books and books with notes.
- He noticed that there is a geographical pattern in the distribution of different social categories: people who live in a particular neighbourhood and share similar living conditions, are of similar characteristics and social status.

Charles Booth



Maps Descriptive of London Poverty 1889. Charles Booth's *Inquiry into Life and Labour in London (1886-1903).*

Charles Booth

Classification	Colour	
Lowest class. Vicious, semi-criminal.	Black	
Very poor, casual. Chronic want.	Dark blue	
Poor. 18s. to 21s. a week for a moderate family.	Light blue	
Mixed. Some comfortable others poor.	Purple	
Fairly comfortable. Good ordinary earnings.	Pink	
Middle class. Well-to-do.	Red	
Upper-middle and upper classes. Wealthy.	Yellow	

Geodemographics

- Further developed in 1970s to target urban deprivation funding.
- Commercial sector also got involved (CACI ACORN / Experia MOSAIC).
- Office for National Statistics' Output Area Classification (2001, 2011, 2021).
- ONS' Output Area Classification completely open using Census data.

Geodemographics

Singleton *et al.* 2020:

“A geodemographic classification is created by assembling a wide range of measures that describe the characteristics of areas and/or those people living within them, and then, through the implementation of unsupervised learning (clustering), identifies groups of areas that share common characteristics. Emerging clusters may be divided or aggregated to create a hierarchy, and it is typical that these be accompanied by labels, descriptions, photographs, diagrams and graphs.”

Variable selection

Choice of measures can create bespoke classifications:

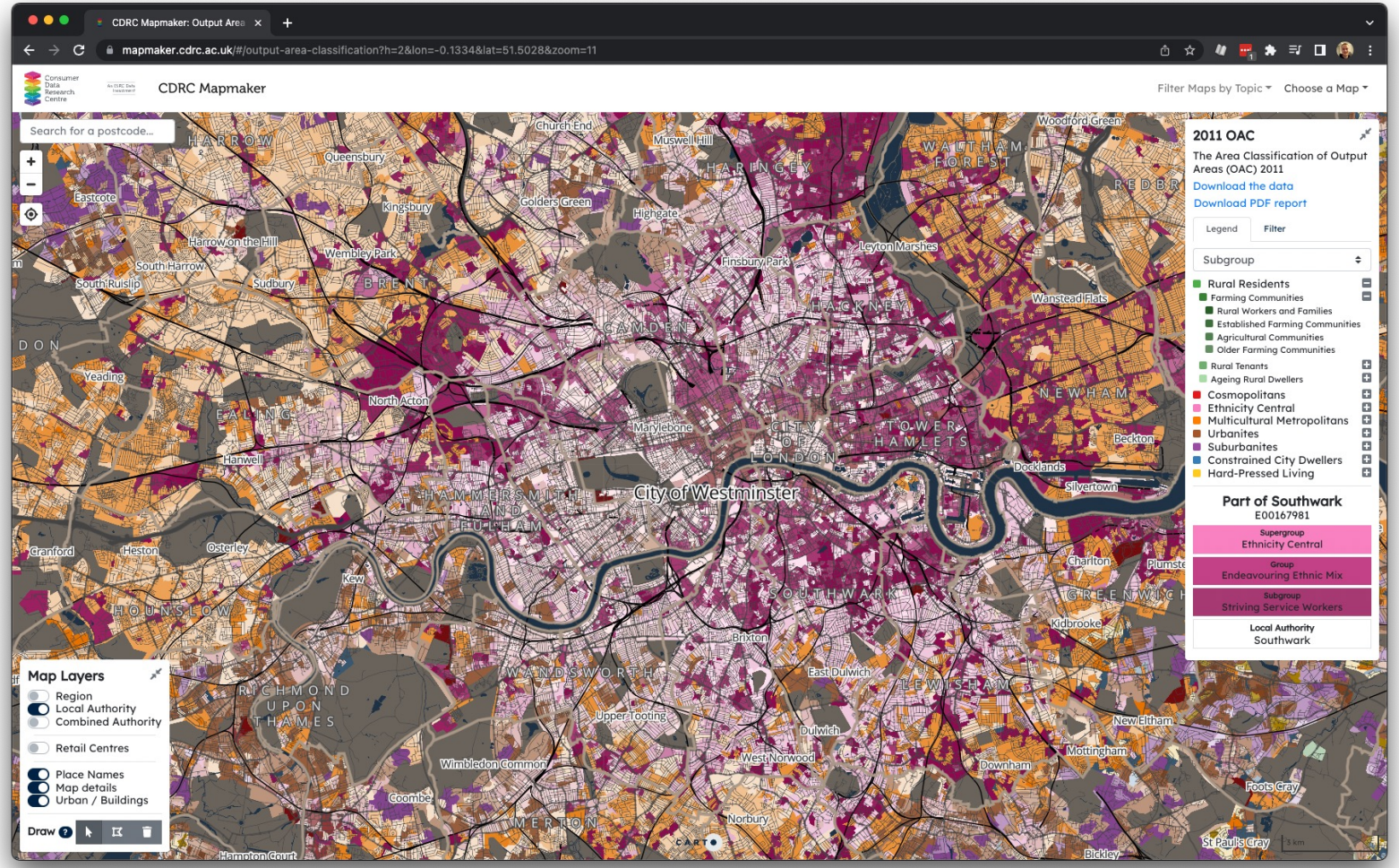
- Output Area Classification: 60 census variables, focused on holistic understanding of area characteristics.
- Workplace Zones Classification: 48 census variables across 4 domains, focused on workers and workplaces.
- Internet User Classification: built from a range of consumer, survey and open (census) data focusing on how populations interact with the internet (use and engagement).

Clustering

Variables are partitioned into clusters using the k-means clustering algorithm and then mapped to their respective areal unit, e.g. Output Area, Workplace Zone:

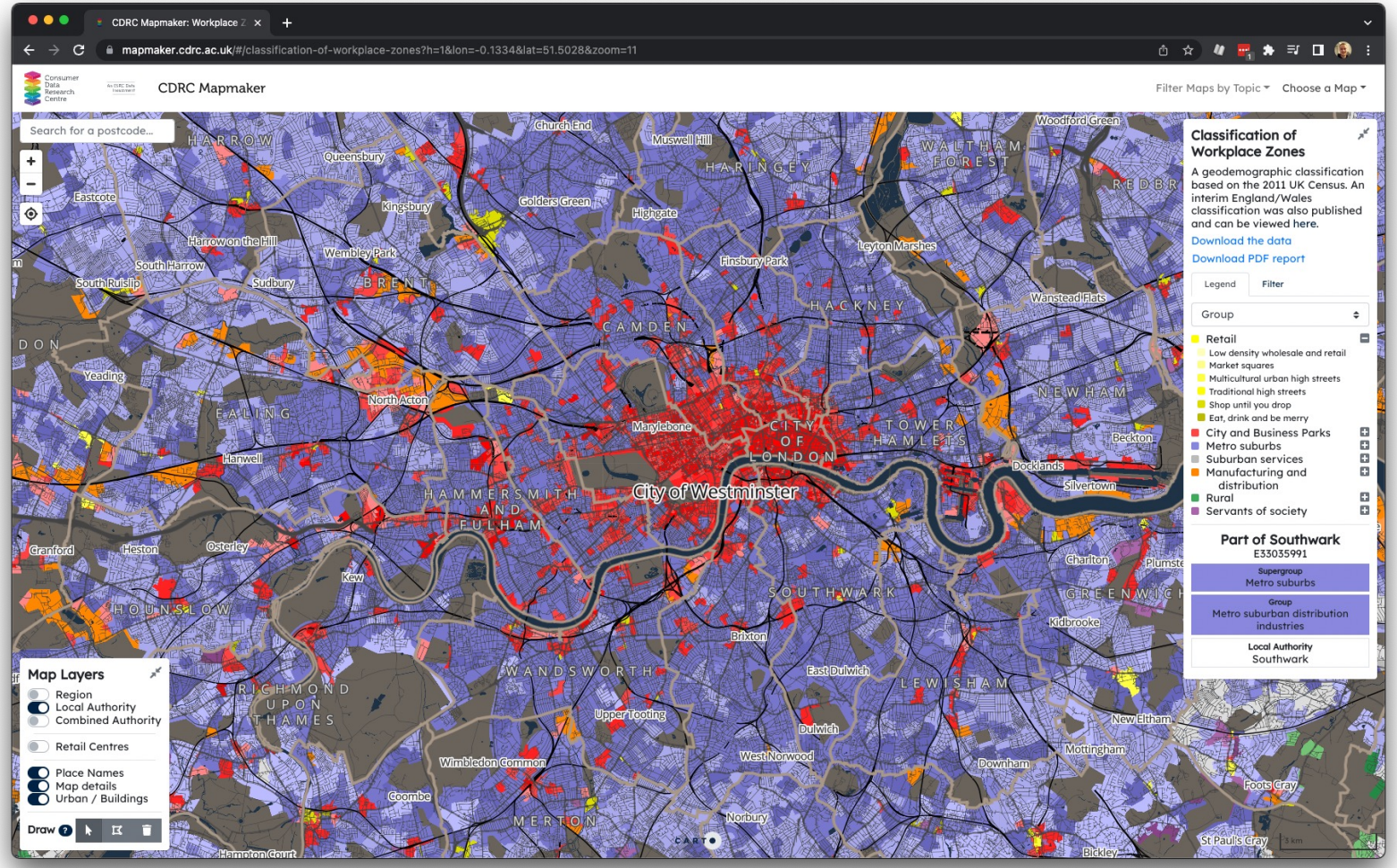
- Sometimes there is a hierarchy of clusters (e.g. supergroups, clustergroups).
- Each cluster will have a name and description (pen portrait).

Geodemographics



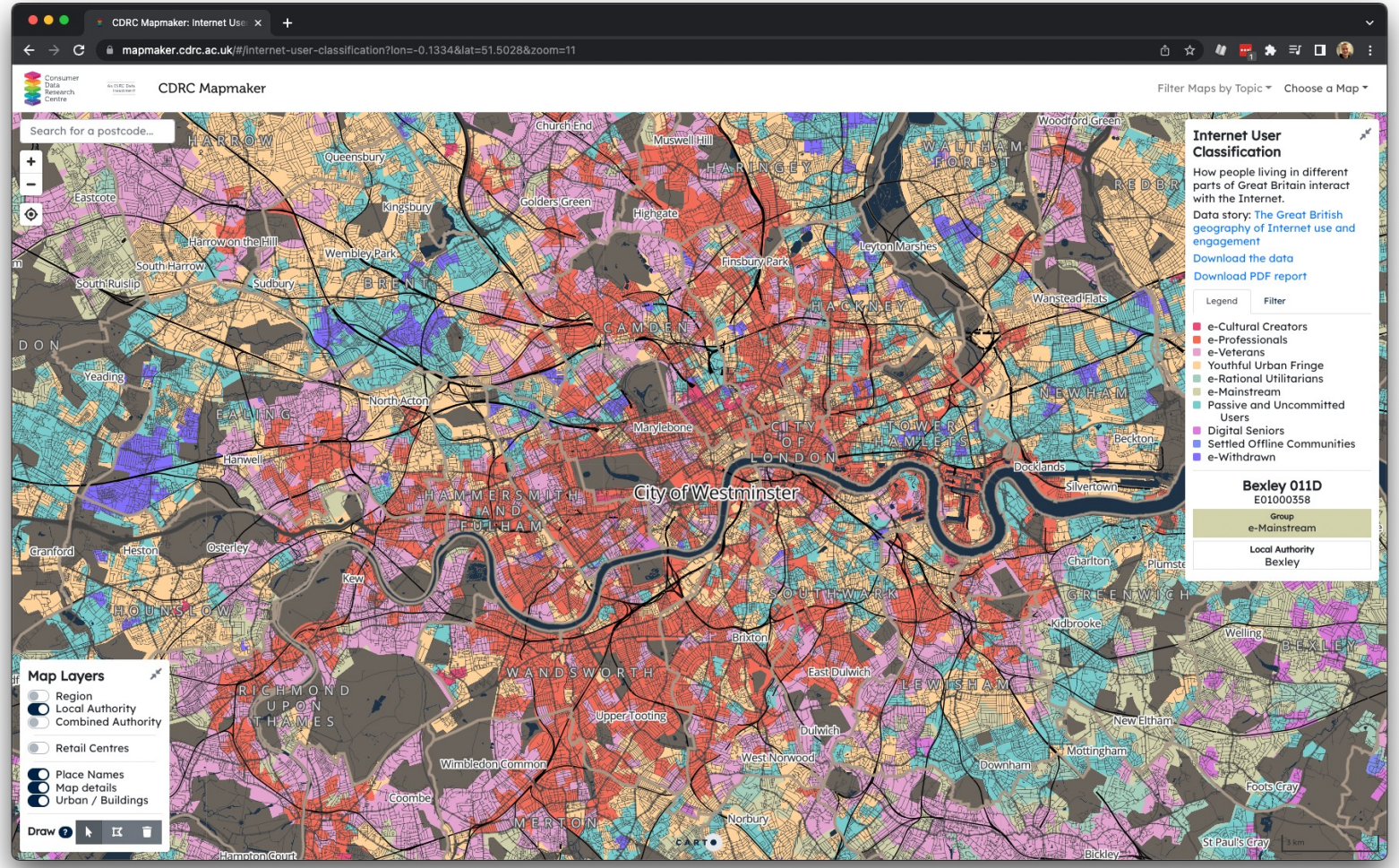
2011 Output Area Classification on mapmapker.cdrc.ac.uk

Geodemographics



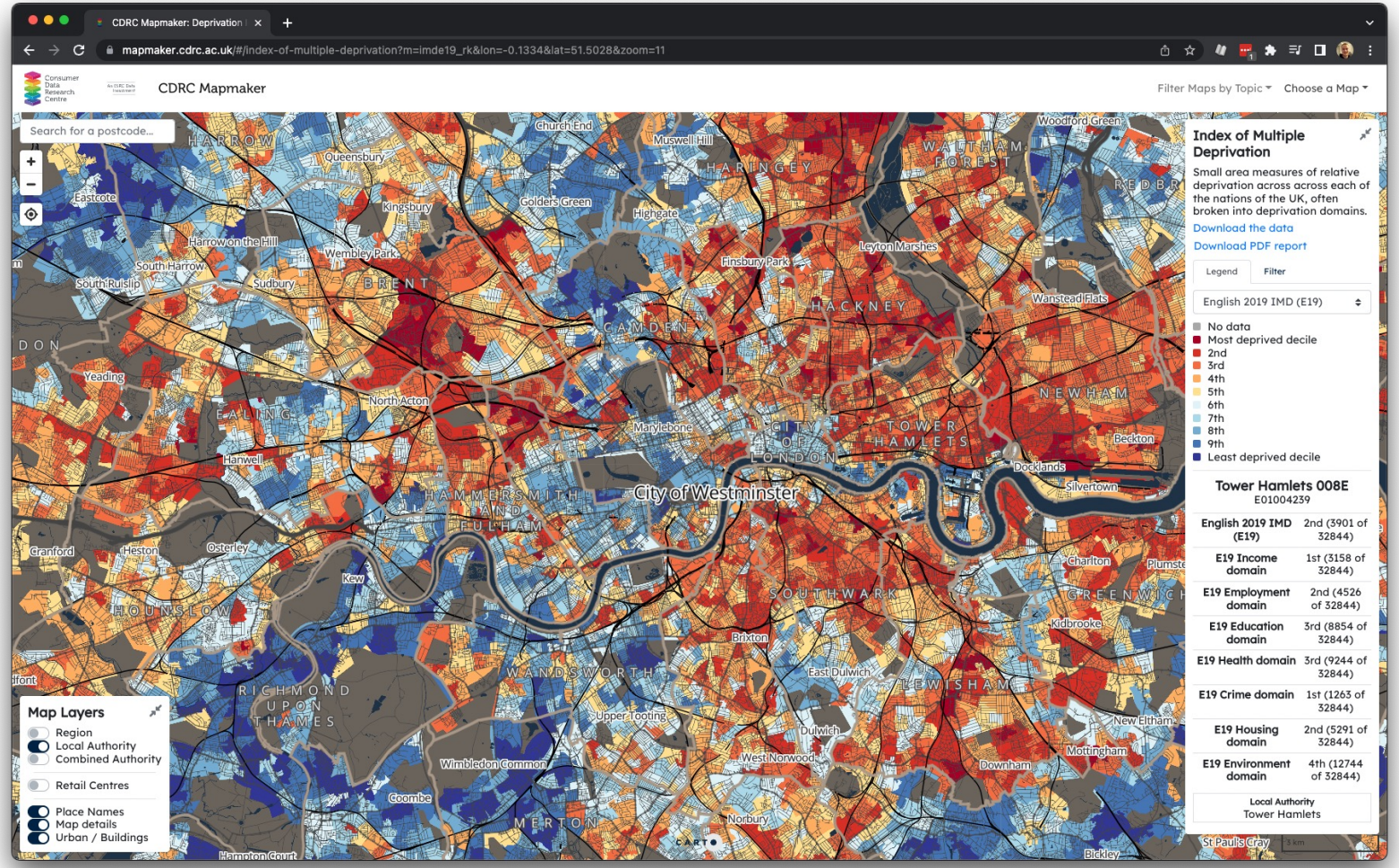
Workplace Zone Classification on mapmapker.cdrc.ac.uk

Geodemographics



Internet User Classification on mapmapker.cdrc.ac.uk

Indices



2019 Index of Multiple Deprivation on mapmapker.cdrc.ac.uk

Limitations

- Highly dependent on the input data.
- Input data can get old very quickly (depending on the topic).
- Inherent biases within the input data – see also the article by Dalton and Thatcher (2015) on the Data, Politics Society reading list.

Applications

Using the geodemographic classification as input for further analysis:

- Harris *et al.* 2007: differences in school choice between social groups
- Brundson *et al.* 2011: participation in higher education
- Martin *et al.* 2018: analysis of travel-to-work flows
- Goodman *et al.* 2011: socio-economic inequalities in exposure to air pollution
- Trasberg and Cheshire 2021: profiling changing activity patterns

Internet user classification

Singleton *et al.* 2020:

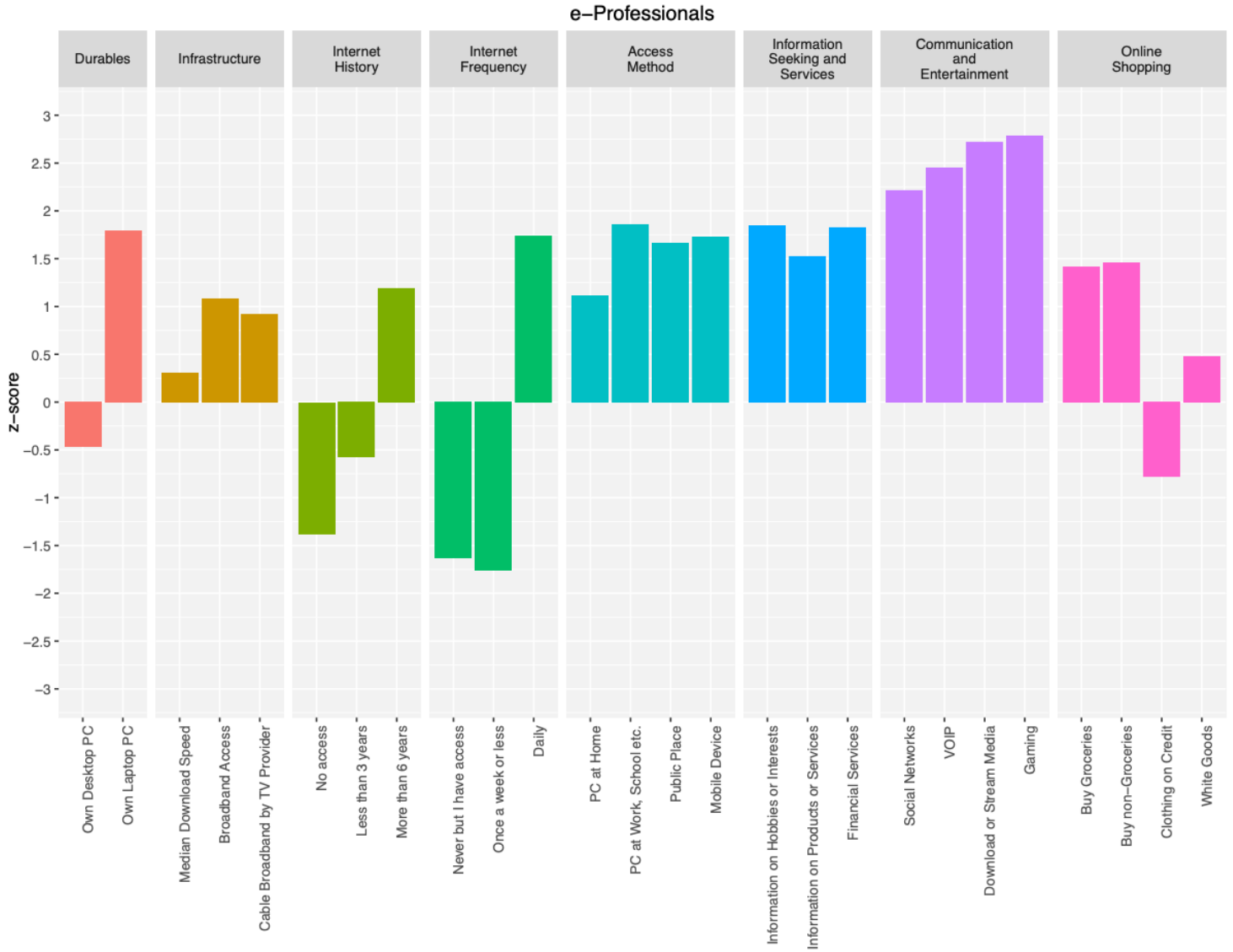
- bespoke classification created by CDRC researchers
- how do populations interact with the internet
- ‘profiles of internet use and engagement’
- built from a range of consumer data, survey data, and open data
- classification is available as open data

Internet user classification

Several noteworthy variables:

- British Population Survey: internet access, frequency of internet usage, access to PC, type of internet use
- transactional (consumer) data on online shopping
- average broadband speed
- census variables such as age, ethnicity
- National Statistics Socio-economic classification (NS-SEC)

Internet user classification



Internet User Classification mean attributes of the *e-Professionals*

Internet user classification

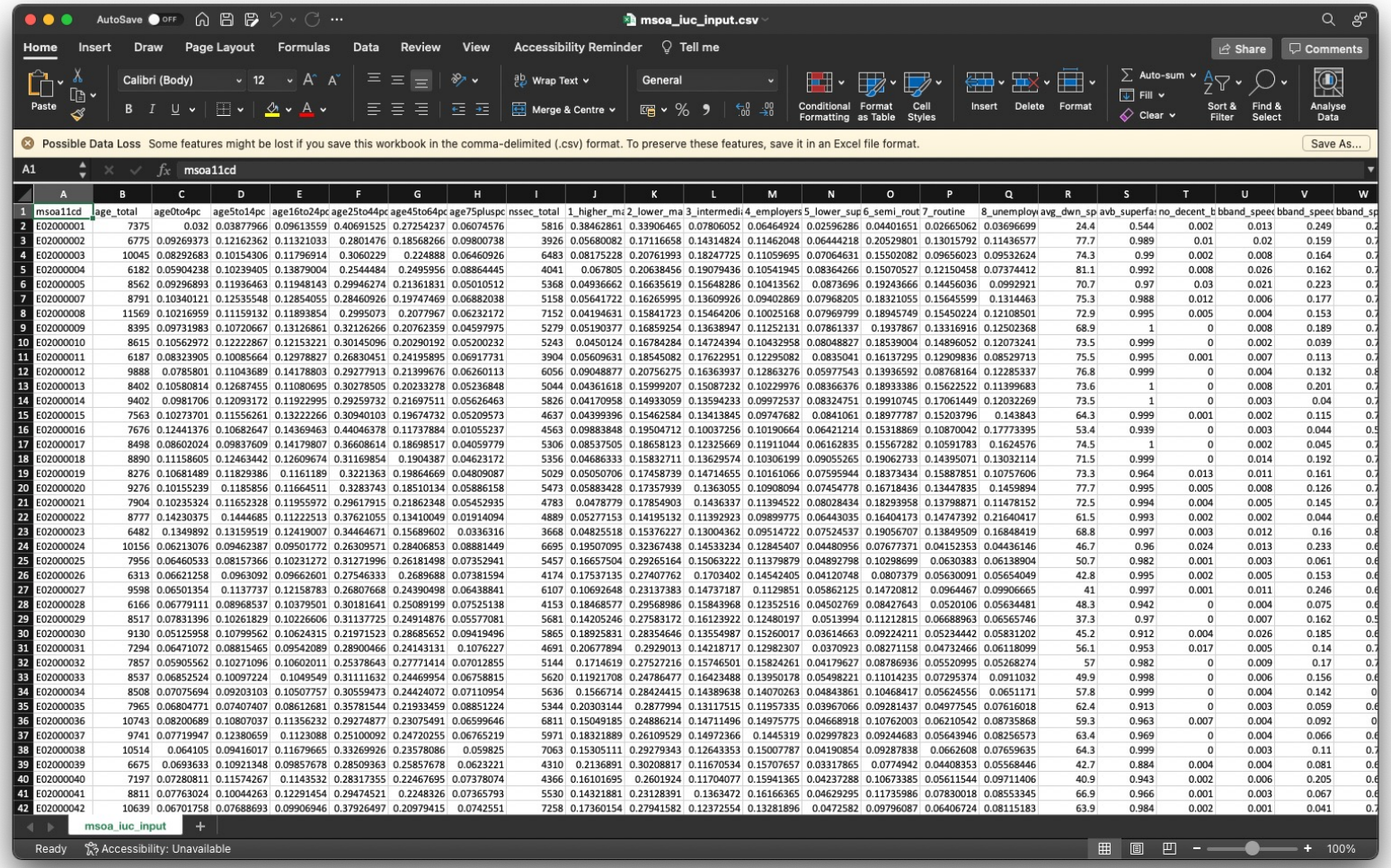
e-Professionals:

“This Group has high levels of Internet engagement, particularly regarding social networks, communication, streaming and gaming, but relatively low levels of online shopping, besides groceries. They are new but very active users, with a very high proportion of the population engaging on a daily basis. (…) Geographically, this Group is mainly located close to the city centre or within the proximity of Higher Education Institutes, where infrastructure accessibility, such as cable broadband, is sufficient”

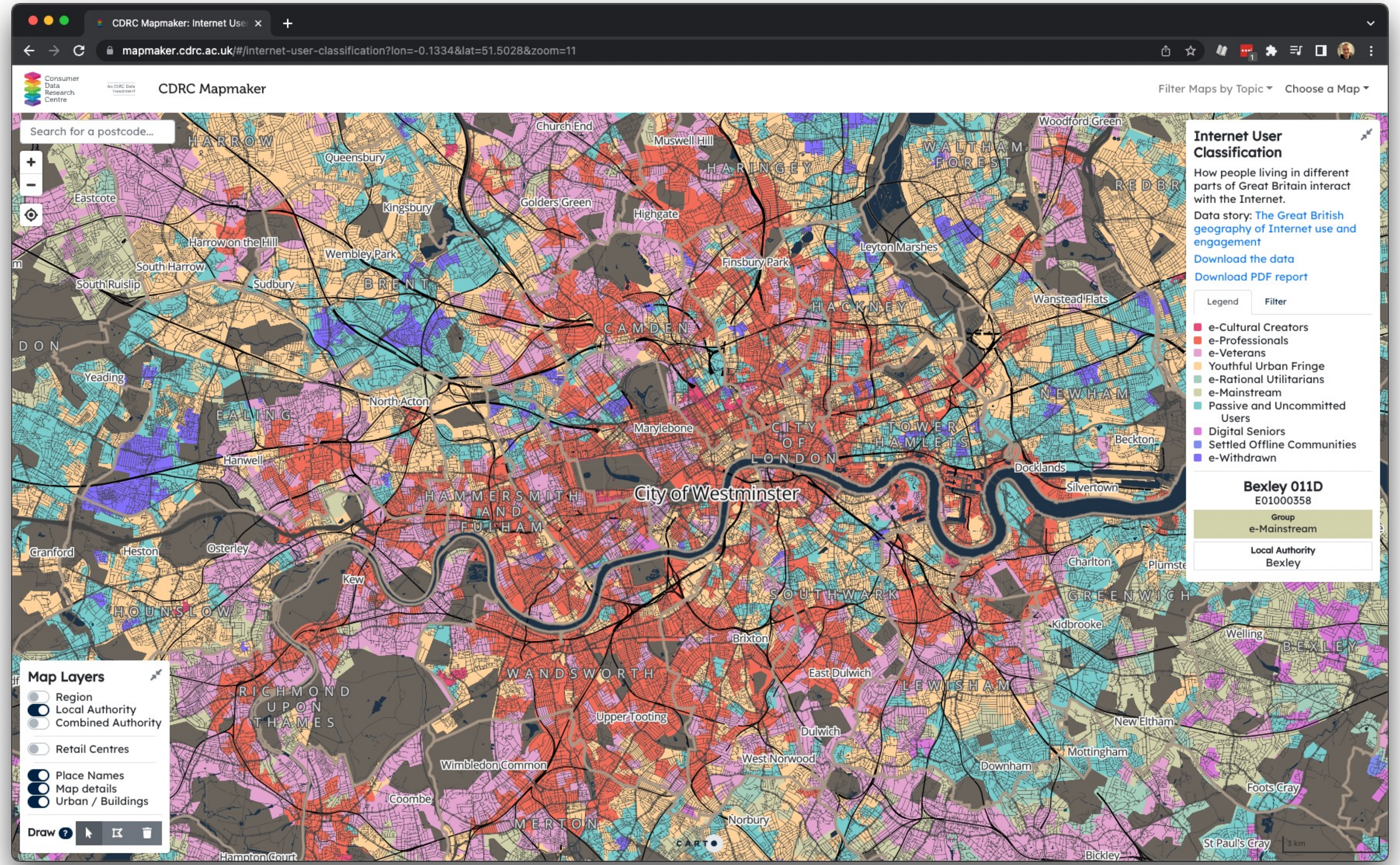
Internet user classification

- Measures of access to and use of internet.
- Identification of areas to target potential interventions.
- Analysis of areas where people are likely to work from home.

Workflow


msoa_iuc_input.csv
Possible Data Loss Some features might be lost if you save this workbook in the comma-delimited (.csv) format. To preserve these features, save it in an Excel file format.
Save As...
A1
msoa11cd
msoa_iuc_input
Ready
Accessibility: Unavailable
100%

Workflow


CDRC Mapmaker: Internet User
mapmaker.cdrc.ac.uk/#/internet-user-classification?lon=-0.1334&lat=51.5028&zoom=11
Consumer Data Research Centre
CDRC Mapmaker
Filter Maps by Topic
Choose a Map
Search for a postcode...
Internet User Classification
How people living in different parts of Great Britain interact with the Internet.
Data story: The Great British geography of Internet use and engagement
Download the data
Download PDF report
Legend
Filter
e-Cultural Creators
e-Professionals
e-Veterans
Youthful Urban Fringe
e-Rational Utilitarians
e-Mainstream
Passive and Uncommitted Users
Digital Seniors
Settled Offline Communities
e-Withdrawn
Bexley 011D
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Group
e-Mainstream
Local Authority
Bexley
Map Layers
Region
Local Authority
Combined Authority
Retail Centres
Place Names
Map details
Urban / Buildings
Draw
City of Westminster
CAMDEN
HACKNEY
HARINGEY
WALTHAM FOREST
NEWHAM
TOWER HAMLETS
CITY OF LONDON
HAMMERSMITH AND FULHAM
EALING
BRENT
HARROW
HOUNSLOW
RICHMOND UPON THAMES
WANDSWORTH
SOUTHWARK
LEWISHAM
GREENWICH
BEXLEY
MERTON
Marylebone
Brixton
Docklands
Kew
CARTO

Workflow

Typical workflow:

1. Choose input domains
2. Select associated quantifiable variables
3. Measure variables for association (multi-collinearity)
4. Transform and standardise variables
5. Choose clustering method
6. Choose number of clusters
7. Interpret findings, test and finalise them

Input domain

- What type of application will your classification be aimed/themed around? What information is relevant?
- What or who are you segmenting? Individuals / Households / Postcodes / Output Areas / Wards ?
- Scale of data available?
- Difficulties to combine different datasets? Temporal mismatch, spatial mismatch?

Variables

Need to select variables that are associated with application or phenomenon you are trying to classify within the population you are looking to segment:

- Partially subjective – what you choose will affect the results.
- No single or unique set of variables.
- Balancing act of theory, available data and statistical considerations.
- Selection of variables directly impact what is classified.

Multi-collinearity

Use of correlation matrix – correlated or not?

- Coefficient (or r-square value) is presented on a scale between -1 and 1.
- The greater the value, the greater the association between the two variables.
- Set an appropriate threshold - as a rule of thumb, two variables with coefficients greater than ±0.8 can be considered to be highly correlated.
- Remove the variable which correlates the greatest with the other variables in the matrix to leave most unique one.
- May replace or keep variable with ”convincing argument”.

Standardise variables

Normalise to control for non-uniformity of areal units:

- expressing variables as percentages or proportions (e.g. using a relevant population denominator)

Standardise between variables to account for value ranges:

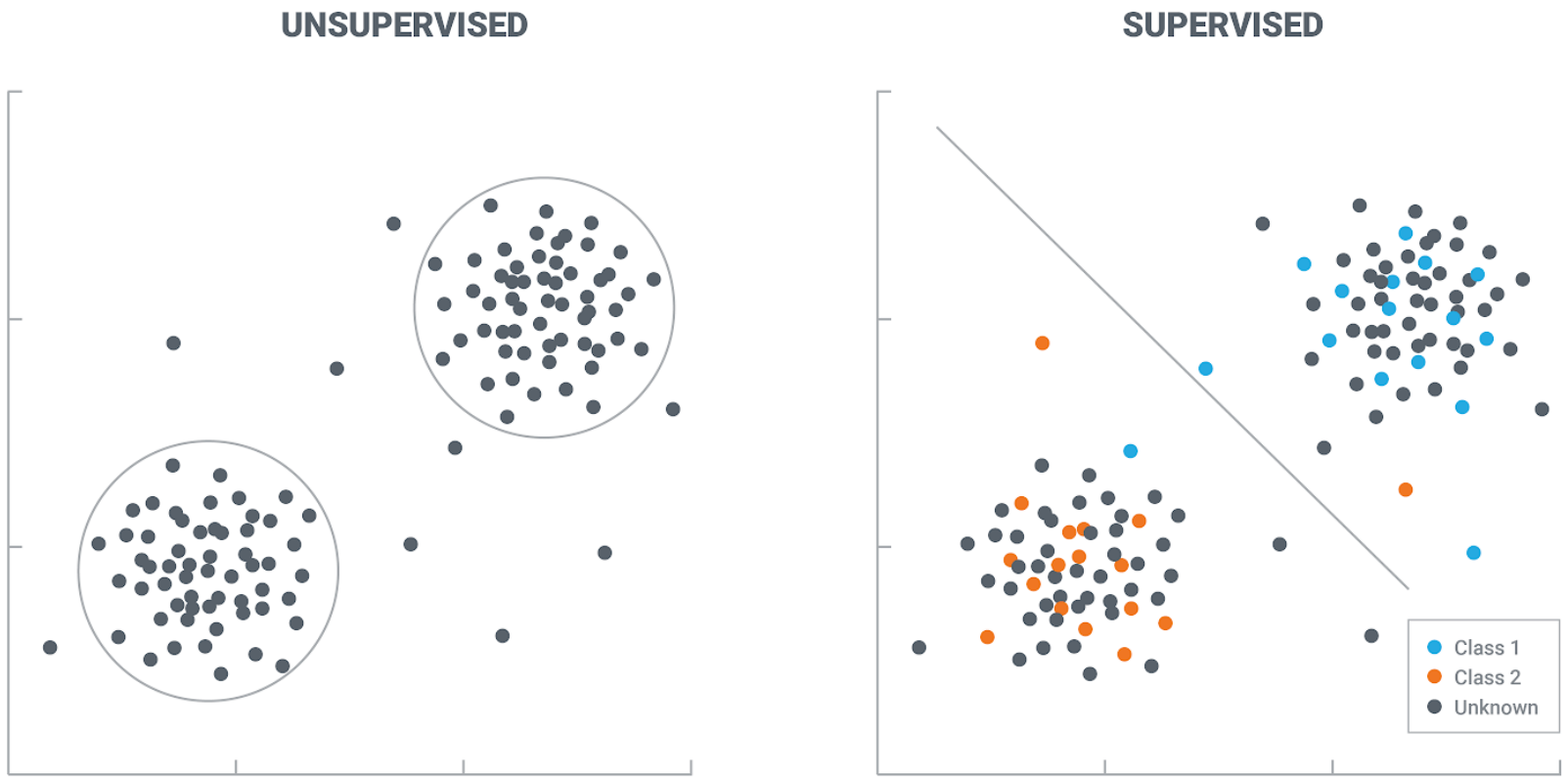
- transform all variables to be on the same scale
- z-scores, range standardisation

Clustering

Use of clustering algorithms to partition demographic data into groups sharing similar characteristics:

- Different methods often create different groups.
- Requires user intuition to decide best outcome and optimal cluster numbers.
- Some methods (such as k-means) create different groups with each run.
- Creating a geodemographic classification therefore sometimes requires running an algorithm multiple times.
- Can be computationally expensive.
- Unsupervised methods used.

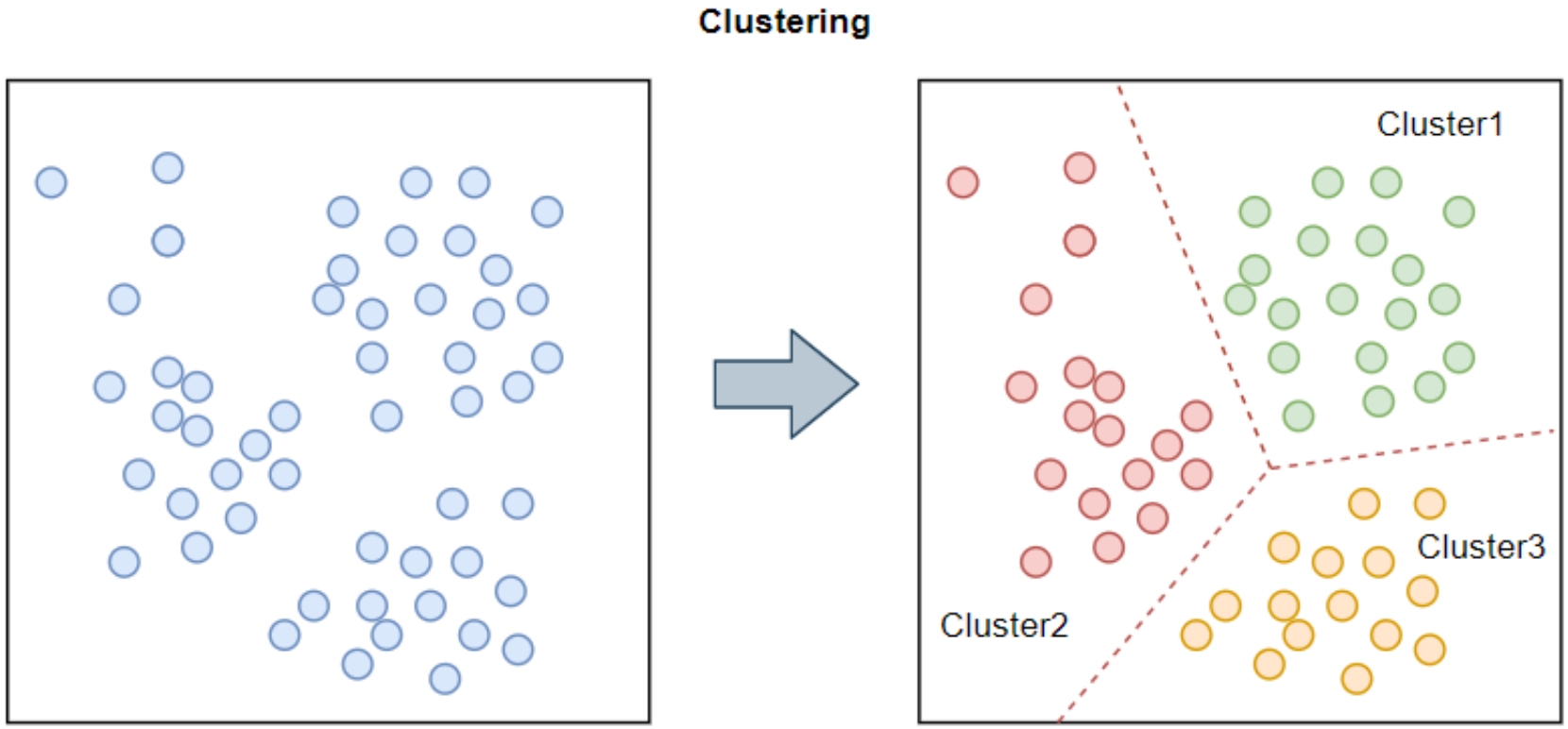
Unsupervised versus supervised



k-means

- Assign geographic areas with common underlying attributes to similar classification groups.
- `k` clusters (pre-defined) of `n` individual observations.
- Each observation can have any number of attribute data.
- Used in: Internet User Classification, ONS 2011 Output Area Classification, ONS 2021 Output Ara Classification.

k-means



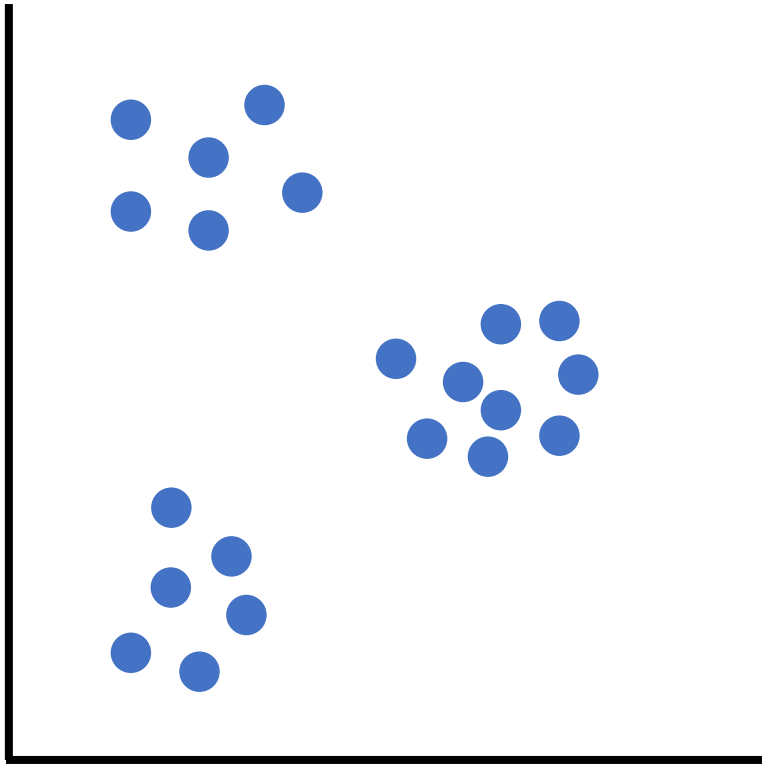
k-means

- Minimising the distance between an observation’s input variables to the means of the respective cluster groups.
- Maximising the distance between cluster groups.
- Number of clusters defined a priori.

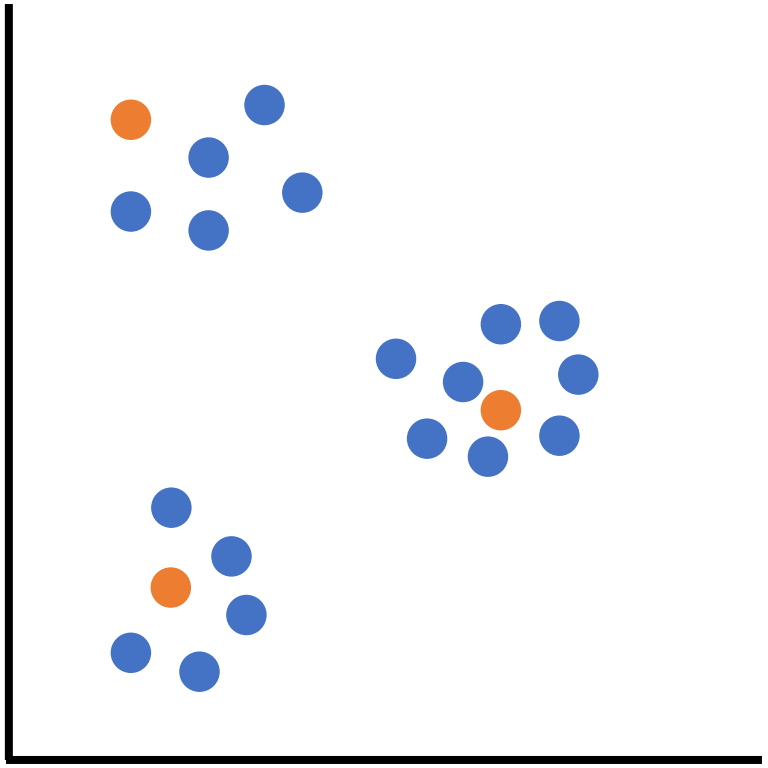
Process

- Step 1: identify your `k`
- Step 2: randomly identify `k` distinct data points as initial cluster centre
- Step 3: assign each observations to the nearest cluster
- Step 4: calculate the mean of each cluster
- Step 5: repeat with mean value becoming new cluster centre until no change

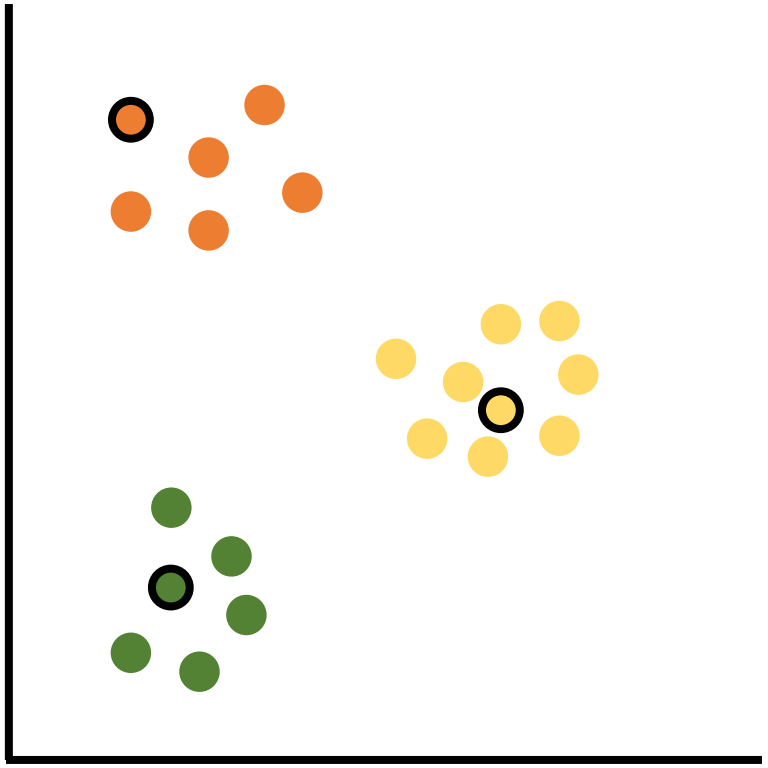
Step 1



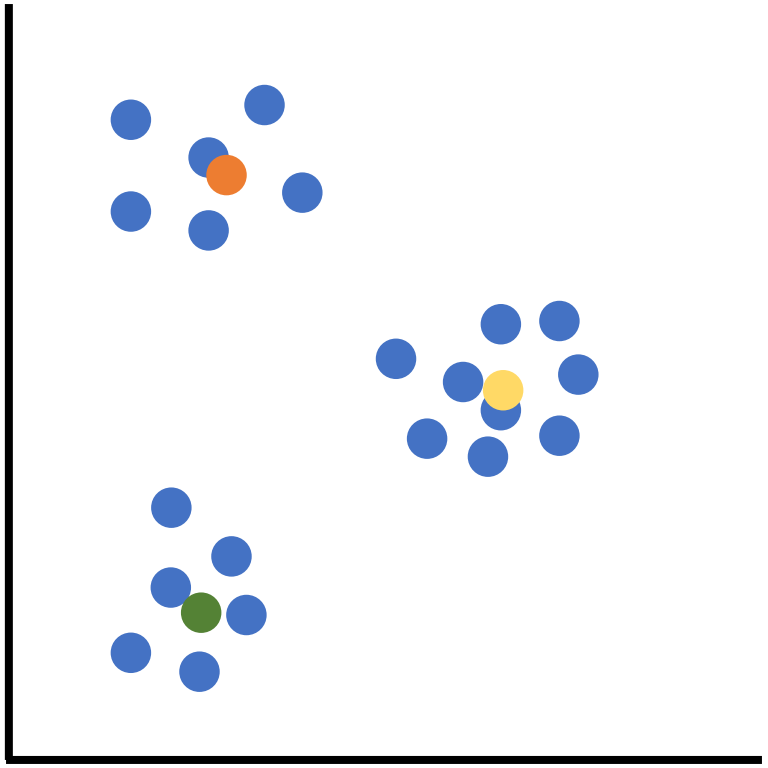
Step 2



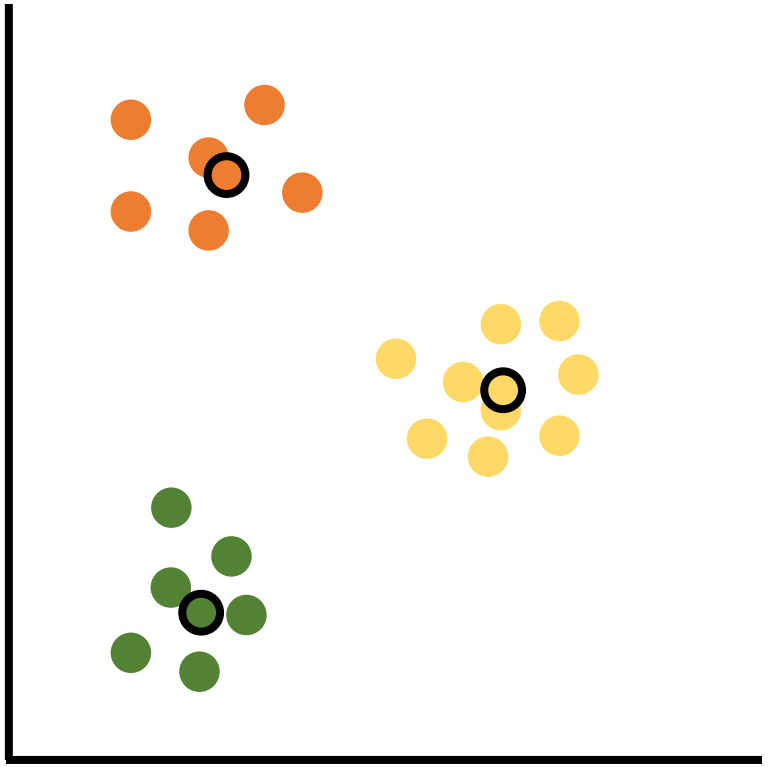
Step 3



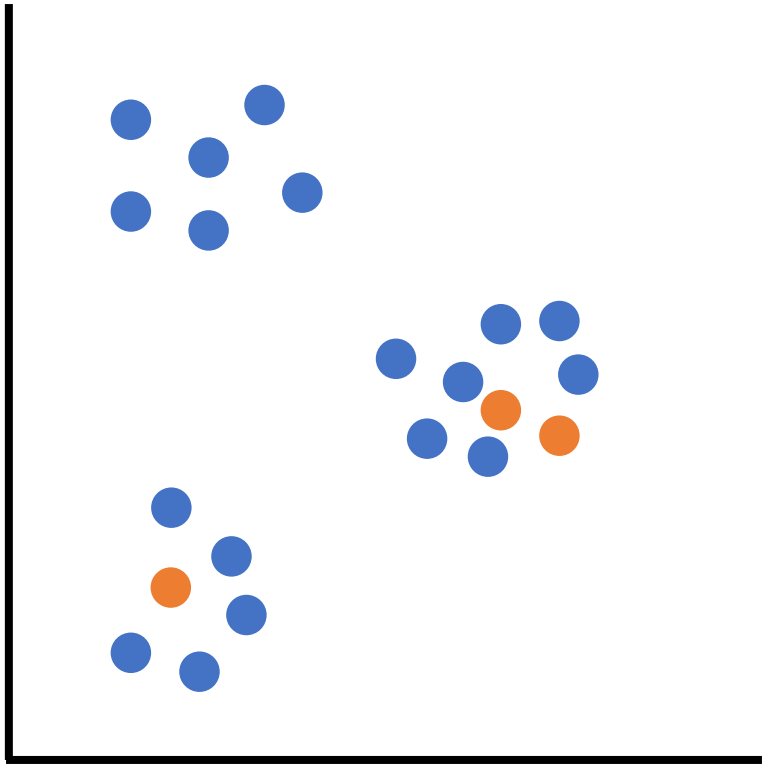
Step 4



Step 5



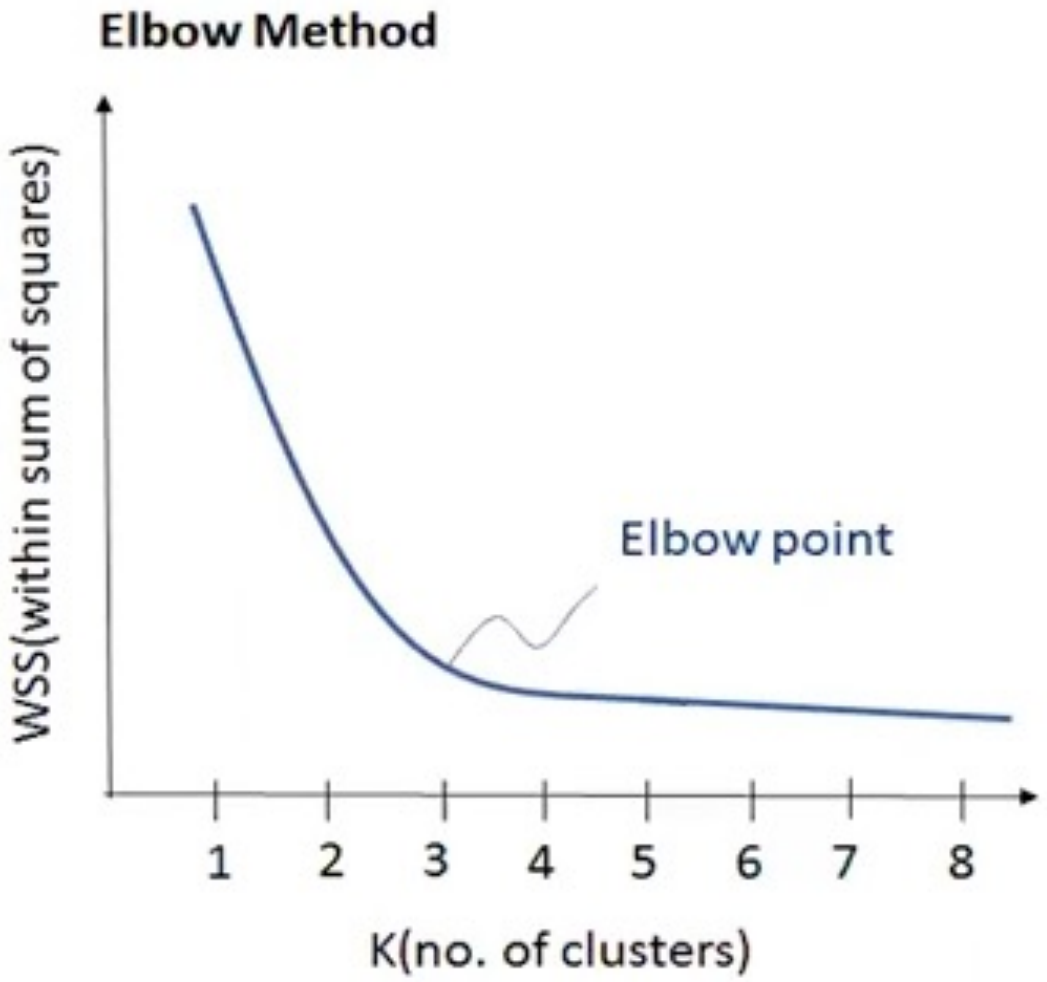
Multiple iterations



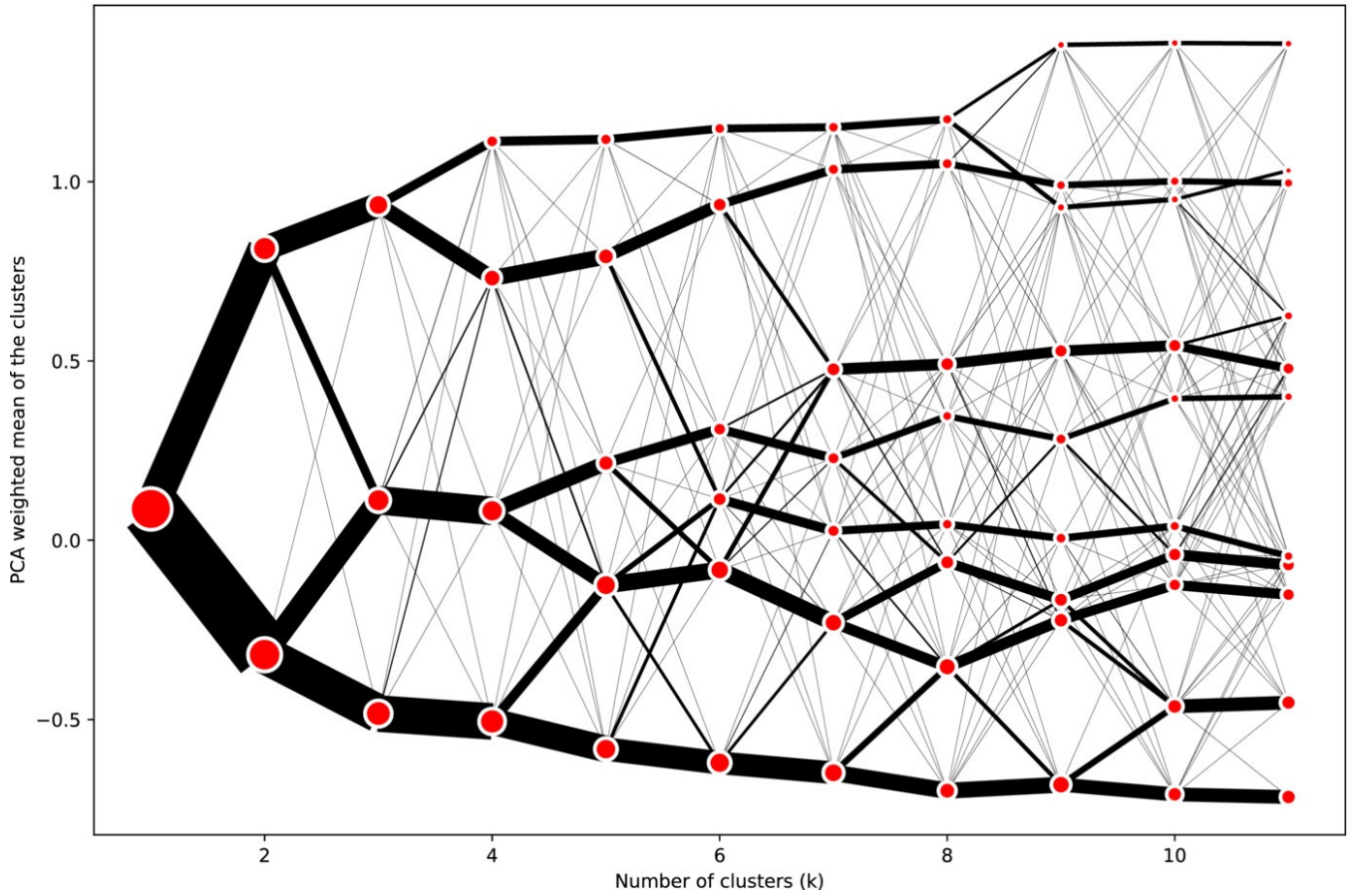
Number of clusters

- Too few: too much variation within the groups.
- Too many: overfitting and splitting similar observations.
- Iterate through the model multiple times and try to minimise variation within cluster groups.

Number of clusters



Number of clusters



Interpretation of clusters

- Look at the means of the input data for each cluster (‘signature’).
- Can use radar or bar plots to characterise the cluster.
- Not spatial in nature (different to the DBSCAN).

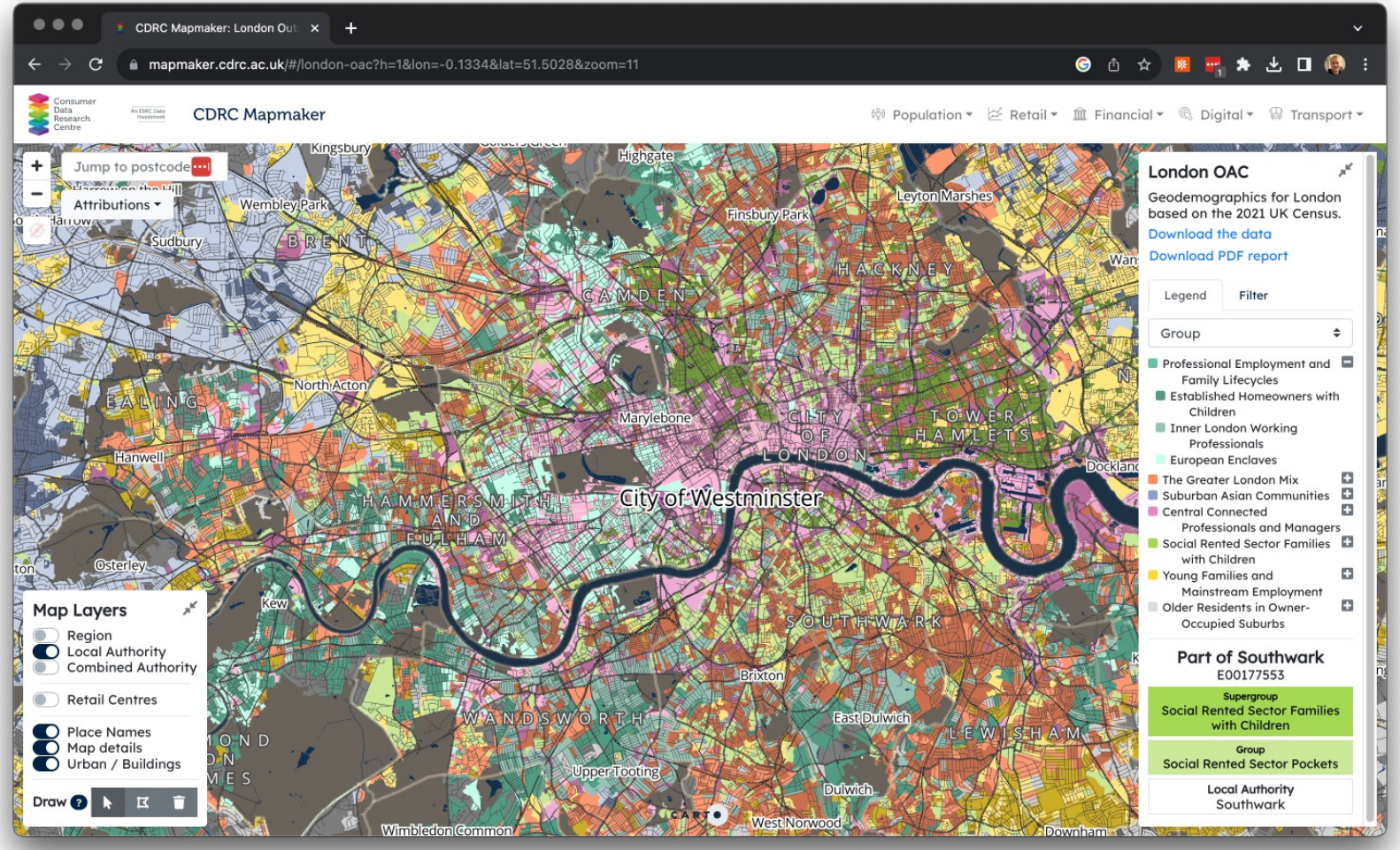
Cluster labels

- Should generalise the characteristics of each group.
- Should be clear for users unfamiliar with geodemographics.
- Should not cause offense to the inhabitants of each group.
- Should not draw on assumptions that cannot be applied by the data.
- Be aware of the unevenness of the ecological fallacy.
- Create pen portraits for easy interpretation.

Conclusion

- Geodemographics as the analysis of people by where they live.
- Typically, a form of unsupervised machine learning is used; k-means.
- Once created: benchmarking against additional quantitative data.
- Sometimes the spatial scale should be re-considered.
- Recent classifications: London Output Area Classification 2021, Output Area Classification England and Wales 2021, UK Output Area Classification 2021.

Conclusion



2021 London Output Area Classification on mapmapker.cdrc.ac.uk

Questions

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