# Big Data & Automated Content Analysis
# Week 4 – Wednesday: »Data Wrangling«

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# Today

# Everything clear from last week?

# Statistics in Python

# Statistics in Python

## General considerations

# General considerations

So you retrieved some cool data from a JSON API, selected some interesting key-value pairs, and maybe also created a rectangular dataframe.

Of course, you can always export to .csv and use R or Stata or SPSS or whatever...

BUT:

# Reasons for not exporting and analyzing somewhere else

- the dataset might be too big
- it's cumbersome and wastes your time
- it may introduce errors and makes it harder to reproduce
- you want to learn Python ;-)

# What statistics capabilities does Python have?

- Basically all standard stuff (bivariate and multivariate statistics) you know from SPSS
- Nowadays: also really advanced stuff (e.g., time series analysis via `statsmodels`; structural equation modelling via `semopy`; ...)
- Yet, for some really specific advanced statistical models, you may want to look somewhere else (else==R)

# Statistics in Python

## Useful packages

# Useful packages

**numpy** (numerical python) Provides a lot of frequently used functions, like mean, standard deviation, correlation, ...

**scipy** (scientic python) More of that ;-)

**statsmodels** Statistical models (e.g., regression or time series)

**matplotlib** Plotting

**seaborn** Even nicer plotting

**plot.ly** Also nicer plotting (+ interactive)

# Example 1: basic numpy

```
1  import numpy as np
2  x = [1,2,3,4,3,2]
3  y = [2,2,4,3,4,2]
4  z = [9.7, 10.2, 1.2, 3.3, 2.2, 55.6]
5  np.mean(x)
```

```
1  2.5
```

```
1  np.std(x)
```

```
1  0.957427107756338 1
```

```
1  np.corrcoef([x,y,z])
```

```
1  array([[ 1.        ,  0.67883359, -0.37256219],
2         [ 0.67883359,  1.        , -0.56886529],
3         [-0.37256219, -0.56886529,  1.        ]])
```

# Example 1: basic numpy

```
1 from scipy.stats import skew, kurtosis
2 for li in (x,y):
3     print(f"Skewness of {li}: {skew(li)}. Kurtosis: {kurtosis(li)}")
```

```
1 Skewness of [1, 2, 3, 4, 3, 2]: 0.0. Kurtosis: -0.942148760330578
2 Skewness of [2, 2, 4, 3, 4, 2]: 0.332709512140237. Kurtosis:
      -1.676575505350732
```

```
1 from scipy.stats import kendalltau, spearmanr, pearsonr
2 print(kendalltau(x,y), spearmanr(x,y), pearsonr(x,y))
```

```
1 KendalltauResult(correlation=0.585369407004963 6, pvalue
      =0.1373671546813069) SpearmanrResult(correlation
      =0.7627700713964739, pvalue=0.07774164094789 97)
      (0.6788335930269976, 0.1381579775049088 8)
```

# Characteristics

- Operates (also) on simple lists
- Returns output in standard datatypes (you can print it, store it, calculate with it, . . . )
- it's fast! `np.mean(x)` is faster than `sum(x)/len(x)`
- it is more accurate (less rounding errors)

# Example 2: basic plotting

```
1  import matplotlib.pyplot as plt
2  x = [1,2,3,4,3,2]
3  y = [2,2,4,3,4,2]
4  plt.hist(x)
5  plt.plot(x,y)
6  plt.scatter(x,y)
```

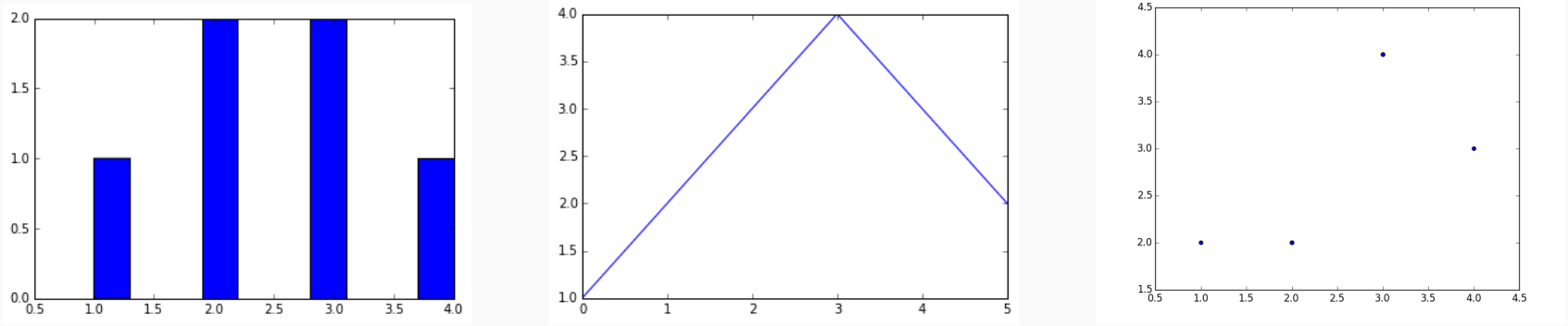


**Figure 1:** Examples of plots generated with `matplotlib`

# Pandas basics

# Pandas basics

## Working with dataframes

# When to use dataframes

## Lists, dicts, generators

pro:

- flexible (especially dicts!)
- fast
- straightforward and easy to understand

con:

- if your data is a table, modeling this as, e.g., lists of lists feels unintuitive
- very low-level: you need to do much stuff 'by hand'

## Pandas dataframes

pro:

- like an R dataframe or a STATA or SPSS dataset
- many built-in methods for statistics, plotting, grouping, subsetting, . . . )

con:

- 'overkill' if you just want correlate two lists or so
- unsuitable for REALLY large datasets

# Pandas basics

## Plotting and calculating with Pandas

More examples here: https://github.com/annekroon/bdaca-6ec/tree/master/6ec/week04/examples/basic_statistics.ipynb

# OLS regression in pandas

```
1  import pandas as pd
2  import statsmodels.formula.api as smf
3
4  df = pd.DataFrame({'income': [10,20,30,40,50], 'age': [20, 30, 10, 40,
       50], 'facebooklikes': [32, 234, 23, 23, 42523]})
5
6  myfittedregression = smf.ols(formula='income ~ age + facebooklikes',
       data=df).fit()
7  print(myfittedregression.summary())
```

```
OLS Regression Results
==============================================================================
Dep. Variable:                 income  R-squared:                       0.579
Model:                            OLS  Adj. R-squared:                  0.158
Method:                 Least Squares  F-statistic:                     1.375
Date:                Mon, 05 Mar 2018  Prob (F-statistic):              0.421
Time:                        18:07:29  Log-Likelihood:                -18.178
No. Observations:                   5  AIC:                             42.36
Df Residuals:                       2  BIC:                             41.19
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
coef    std err          t      P>|t|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
Intercept      14.9525    17.764     0.842     0.489      -61.481   91.386
age             0.4012     0.650     0.617     0.600       -2.394    3.197
facebooklikes   0.0004     0.001     0.650     0.583       -0.002    0.003
==============================================================================
Omnibus:                        nan  Durbin-Watson:                   1.061
Prob(Omnibus):                  nan  Jarque-Bera (JB):                0.498
Skew:                        -0.123  Prob(JB):                        0.780
Kurtosis:                     1.474  Cond. No.                     5.21e+04
==============================================================================
```

# Other cool df operations

**df['age'].plot()** to plot a column

**df['age'].describe()** to get descriptive statistics

**df['age'].value_counts()** to get a frequency table

and MANY more...

# Recoding and transforming

To transform your data, you can use (amongst others) `.apply()`, `.applymap()`, and `.map()` or the .str.XXX() methods:

```
1 df['is_center'] = df['hood'].str.contains('[cC]enter')
```

or define your own function:

```
1 def is_center(x):
2     return int(x.lower().find('center') > -1)
3
4 df['is_center'] = df['hood'].map(is_center)
```

or use a throwaway-function:

```
1 df['is_center'] = df['hood'].map(lambda x: int(x.lower().find('center')
      > -1))
```

or use `.replace()` for simple recoding based on lists or a dict (not shown, see https://pandas.pydata.org/pandas-docs/stable/reference/

# Pandas II: Data wrangling

# Pandas II: Data wrangling

## Subsetting and slicing

# Subsetting and slicing

# Subsetting and slicing

Recap:

- `[0:5]` to get elements 0, 1, 2, 3, 4 (works with lists, dataframes . . . )
- `mydict['keyicareabout']` to get value (content) associated with the key

And therefore, also:

- `df[['col1', 'col2']]` to get only these two columns of a dataset
- `df[df['col1']=='whatever']` to get only the rows in which col1 is identical to the string 'whatever'
- `df[df['col2']>0]` to get only the rows in which col2 is a number bigger than 0

# More subsetting

To get a apecific row and/or column, you can use `.iloc[]` and `.loc[]`

- `.iloc[]` takes an int (the row/column numbers, `.loc[]` the names)
- `df.iloc[0,5]` to get row 0, column 5
- `df.loc[0,'what']` to get row 0, column 'what'

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Code CellToolbar

In [7]:
```
df.head()
```

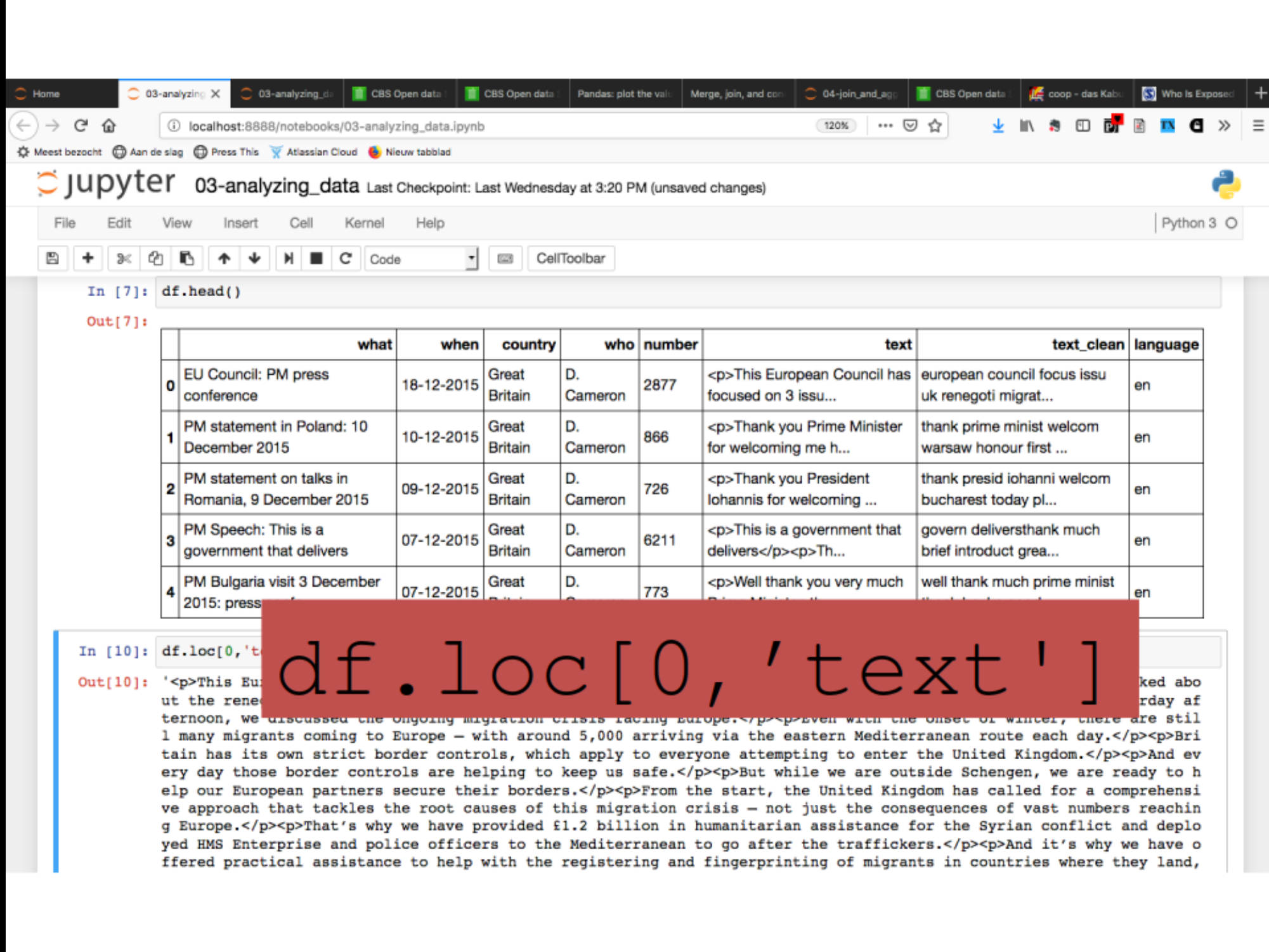
Out[7]:

| | what | when | country | who | number | text | text_clean | language |
|---|---|---|---|---|---|---|---|---|
| 0 | EU Council: PM press conference | 18-12-2015 | Great Britain | D. Cameron | 2877 | This European Council has focused on 3 issu... | european council focus issu uk renegoti migrat... | en |
| 1 | PM statement in Poland: 10 December 2015 | 10-12-2015 | Great Britain | D. Cameron | 866 | Thank you Prime Minister for welcoming me h... | thank prime minist welcom warsaw honour first ... | en |
| 2 | PM statement on talks in Romania, 9 December 2015 | 09-12-2015 | Great Britain | D. Cameron | 726 | Thank you President Iohannis for welcoming ... | thank presid iohanni welcom bucharest today pl... | en |
| 3 | PM Speech: This is a government that delivers | 07-12-2015 | Great Britain | D. Cameron | 6211 | This is a government that delivers Th... | govern deliversthank much brief introduct grea... | en |
| 4 | PM Bulgaria visit 3 December 2015: press | 07-12-2015 | Great | D. | 773 | Well thank you very much | well thank much prime minist | en |

In [9]:
```
df.iloc[0,5
```

df.iloc[0,5]

Out[9]:
```
'<p>This Eu                                                                    ked abo
ut the rene                                                                    rday af
ternoon, we discussed the ongoing migration crisis facing Europe.</p><p>Even with the onset of winter, there are stil
l many migrants coming to Europe – with around 5,000 arriving via the eastern Mediterranean route each day.</p><p>Bri
tain has its own strict border controls, which apply to everyone attempting to enter the United Kingdom.</p><p>And ev
ery day those border controls are helping to keep us safe.</p><p>But while we are outside Schengen, we are ready to h
elp our European partners secure their borders.</p><p>From the start, the United Kingdom has called for a comprehensi
ve approach that tackles the root causes of this migration crisis – not just the consequences of vast numbers reachin
g Europe.</p><p>That's why we have provided £1.2 billion in humanitarian assistance for the Syrian conflict and deplo
yed HMS Enterprise and police officers to the Mediterranean to go after the traffickers.</p><p>And it's why we have o
ffered practical assistance to help with the registering and fingerprinting of migrants in countries where they land,
```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120%
Meest bezocht
Aan de slag
Press This
Atlassian Cloud
Nieuw tabblad
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03-analyzing_data
Last Checkpoint: Last Wednesday at 3:20 PM (unsaved changes)
File
Edit
View
Insert
Cell
Kernel
Help
Python 3
Code
CellToolbar
In [7]: df.head()
Out[7]:
what
when
country
who
number
text
text_clean
language
0
EU Council: PM press conference
18-12-2015
Great Britain
D. Cameron
2877
This European Council has focused on 3 issu...
european council focus issu uk renegoti migrat...
en
1
PM statement in Poland: 10 December 2015
10-12-2015
Great Britain
D. Cameron
866
Thank you Prime Minister for welcoming me h...
thank prime minist welcom warsaw honour first ...
en
2
PM statement on talks in Romania, 9 December 2015
09-12-2015
Great Britain
D. Cameron
726
Thank you President Iohannis for welcoming ...
thank presid iohanni welcom bucharest today pl...
en
3
PM Speech: This is a government that delivers
07-12-2015
Great Britain
D. Cameron
6211
This is a government that delivers Th...
govern deliversthank much brief introduct grea...
en
4
PM Bulgaria visit 3 December 2015: press
07-12-2015
Great
D.
773
Well thank you very much
well thank much prime minist
en
In [10]: df.loc[0,'t
df.loc[0,'text']
Out[10]: ' This Eu
ked abo
ut the rene
rday af
ternoon, we discussed the ongoing migration crisis facing Europe. Even with the onset of winter, there are stil
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# Advanced Example

Out of a dataset with 1,000 speeches, get the one that talks most about [Tt]error

1. We create a new column to count how many a word is mentioned:
   `df['terror'] = df['speech'].str.count('[Tt]error')`
2. We do
   `df.iloc[df['terror'].idxmax()]`
3. That works because df.iloc[] expects an integer to identify the row number, and `df['terror'].idxmax()` returns an integer (687 in our case)

```
df['terrorrefs'].idxmax()
```

```
687
```

```
df.iloc[687]
```

```
what                 Permanent Link to Press conference in Islamabad
when                                                      14-12-2008
country                                                Great Britain
who                                                          G. Brown
number                                                           2954
text          <p>Transcript of a press conference given by t...
text_clean    transcript press confer given prime minist mr ...
language                                                        en
terrorrefs                                                      44
Name: 687, dtype: object
```

# A note on hard-coded "magic numbers"

Hard-coding "magic numbers" like `687` or `(0, 5)` in the examples above is really bad style and should be avoided. Always *calculate* them from your data.

If you *really* cannot do this, define them as a constant at the beginning of your script: `ROW_WITH_CORRUPT_DATA=438`.)

# Pandas II: Data wrangling

## Joining and Merging

# Joining and Merging

## Typical scenario

- You have two datasets that share one column
- For instance, data from www.cbs.nl: one with economic indicators, one with social indicators
- You want to make one dataframe

```
economie = pd.read_csv('82800ENG_UntypedDataSet_15112018_205454.csv', delimiter=';')
economie.head()
```

| | ID | EconomicSectorsSIC2008 | Regions | Periods | GDPVolumeChanges_1 |
|---|---|---|---|---|---|
| 0 | 132 | T001081 | PV20 | 1996JJ00 | 9.3 |
| 1 | 133 | T001081 | PV20 | 1997JJ00 | -2.0 |
| 2 | 134 | T001081 | PV20 | 1998JJ00 | -0.9 |
| 3 | 135 | T001081 | PV20 | 1999JJ00 | -0.7 |
| 4 | 136 | T001081 | PV20 | 2000JJ00 | 1.5 |

```
population = pd.read_csv('37259eng_UntypedDataSet_15112018_204553.csv', delimiter=';')
population.head()
```

| | ID | Sex | Regions | Periods | LiveBornChildrenRatio_3 |
|---|---|---|---|---|---|
| 0 | 290 | T001038 | PV20 | 1960JJ00 | 18.6 |
| 1 | 291 | T001038 | PV20 | 1961JJ00 | 18.9 |
| 2 | 292 | T001038 | PV20 | 1962JJ00 | 18.9 |
| 3 | 293 | T001038 | PV20 | 1963JJ00 | 19.5 |
| 4 | 294 | T001038 | PV20 | 1964JJ00 | 19.6 |

What do you think: How could/should a joined table look like?

First clean up...

```
# remove unnecessary columns
economie.drop('ID',axis=1,inplace=True)
population.drop('ID',axis=1,inplace=True)
# remove differentiation by sex
population = population[population['Sex']=='T001038']
population.drop('Sex',axis=1,inplace = True)
# keep only rows of economie dataframe that contain the total economic activity
economie = economie[economie['EconomicSectorsSIC2008']=='T001081   ']
economie.drop('EconomicSectorsSIC2008', axis=1, inplace=True)
```

```
# remove those evil spaces at the end of the names of the provinces
population['Regions'] = population['Regions'].map(lambda x: x.strip())
economie['Regions'] = economie['Regions'].map(lambda x: x.strip())
```

```
population.merge(economie, on=['Periods','Regions'], how='inner')
```

| | Regions | Periods | LiveBornChildrenRatio_3 | GDPVolumeChanges_1 |
|---|---|---|---|---|
| **0** | PV20 | 1996JJ00 | 11.0 | 9.3 |
| **1** | PV20 | 1997JJ00 | 11.4 | -2.0 |
| **2** | PV20 | 1998JJ00 | 11.6 | -0.9 |
| **3** | PV20 | 1999JJ00 | 11.6 | -0.7 |
| **4** | PV20 | 2000JJ00 | 11.5 | 1.5 |
| **5** | PV20 | 2001JJ00 | 11.7 | 3.9 |
| **6** | PV20 | 2002JJ00 | 11.4 | 2.1 |

Then merge

# On what do you want to merge/join?

Standard behavior of.join(): on the row index (i.e., the row number, unless you changed it to sth else like a date)

```
1 df3 = df1.join(df2)
```

But that's only meaningful if the indices of df1 and df2 mean the same. Therefore you can also join on a column if both dfs have it:

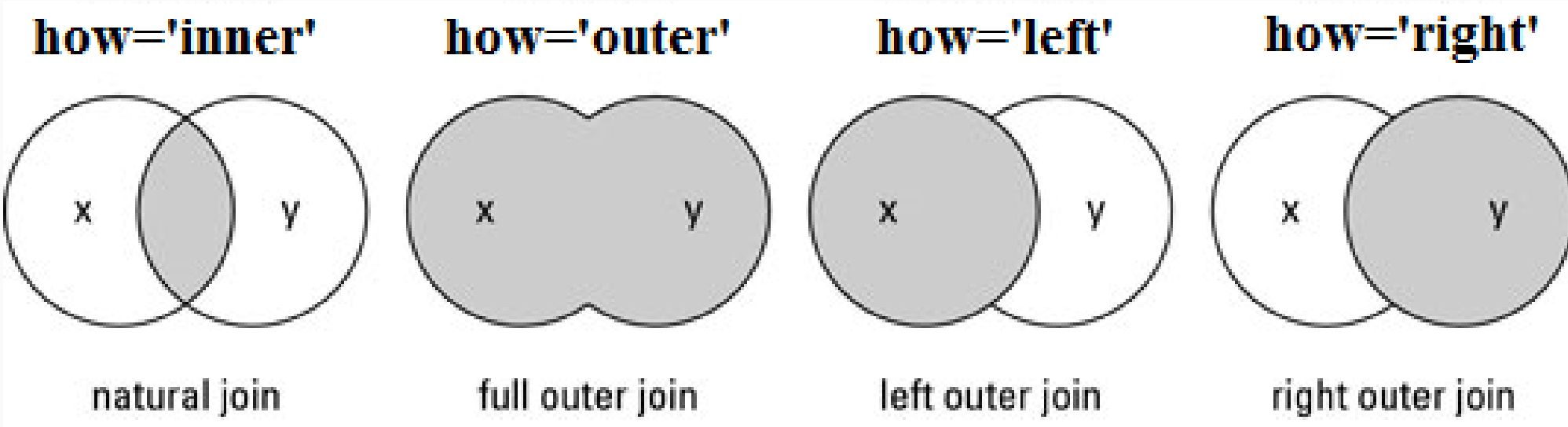
```
1 df3 = df1.merge(df2, on='Regions')
```

`.merge()` is the more powerful tool, `.join()` is a bit easier when joining ion indices.

# Inner, Outer, Left, and Right

Main question: What do you want to do with keys that exist only in one of the dataframes?

```
df3 = df1.join(df2, how='xxx')
```



# Pandas II: Data wrangling

## Aggregation

# Aggregation

# An example

- Suppose you have two dataframes, both containing information on something per region per year.
- You want to merge (join) the two, however, in one of them, the information is also split up by age groups. You don't want that.
- How do you bring these rows back to one row? With `.agg()`!

# .agg()

- Very useful after a `.groupby()`
- Takes a function as argument:

```
df2 = df.groupby('region').agg(sum)
```

- Or multiple functions:

```
df2 = df.groupby('region').agg([sum, np.mean])
```

- $\rightarrow$ yes, you could do `.describe()`, but `.agg()` is more flexible

## Exercise

Can you understand the code (join_and_aggregate.ipynb) and explain to a classmate?

https://github.com/annekroon/bdaca-6ec/tree/master/6ec/week04/exercises

# Next steps

## Friday: Visualization in Python

- First part: I'll walk you through different libraries
- Second part: Take a dataset of your choice and try to apply the techniques discussed.

## Take home exam: Thursday 29 April to Monday evening 3 May

Three parts:

1. Essay-like literature question
2. Programming task ("analyze this dataset", "write a program that does X")
3. Methods question ("You do not have to implement this right now, but how would you. . . ")