

# Python for scientific research

Data analysis with pandas

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# What we've done so far

- 1 Declare variables using built-in data types and execute operations on them
- 2 Use flow control commands to dictate the order in which commands are run and when
- 3 Encapsulate programs into reusable functions, modules and packages
- 4 Use string manipulation and regex to work with textual data
- 5 Interact with the file system
- 6 Number crunching using NumPy/SciPy
- 7 Publication-ready graphs with Matplotlib
- 8 **Next:** working with data using pandas

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- Time-series analysis

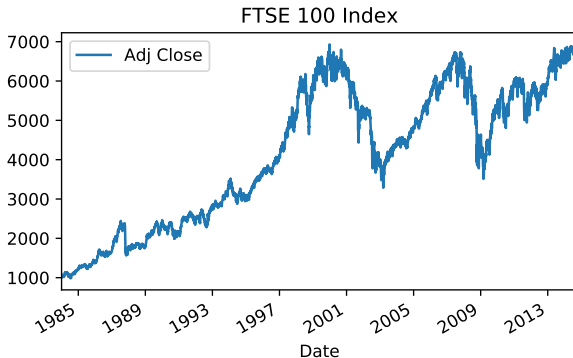
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# Pandas data structures

## 1 Series

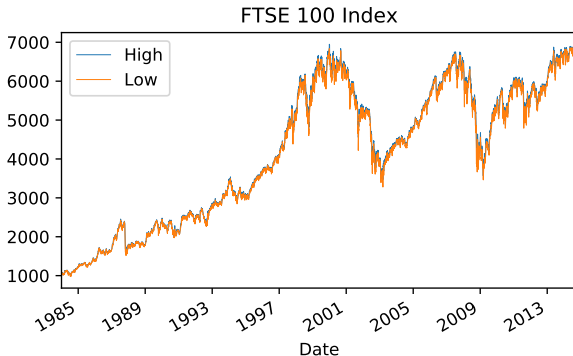
- A one dimensional object
- Similar to a list or array
- Each entry has a unique index
- Useful for time-series analysis



# Pandas data structures

## 2 DataFrame

- A two dimensional object to store data
- Like a spreadsheet with rows and columns (akin to R's `data.frame`)
- Each column is a Pandas Series
- Each row has a unique index
- Useful for any kind of data wrangling and analysis



# Create a DataFrame

```
1 import pandas as pd
2
3 df = pd.DataFrame(
4     {"Sample" : ["R100" , "R201", "R203", "R340", "R453"]
5      ,
6      "t0" : [0.2, 0.1, 0.3, 0.25, 0.13],
7      "t1" : [1.3, 1.8, 0.8, 1.5, 0.6],
8      "t2" : [2.8, 3.1, 1.9, 2.3, 1.8],
9      "t3" : [3.2, 3.7, 2.3, 3.5, 2.5],
10     "t4" : [1.2, 1.8, 3.9, 1.3, 3.7],
11     "t5" : [0.7, 0.4, 3.4, 0.3, 3.6]})
12
13 df.shape # return size of data set (5, 7)
```

	Sample	t0	t1	t2	t3	t4	t5
0	R100	0.20	1.3	2.8	3.2	1.2	0.7
1	R201	0.10	1.8	3.1	3.7	1.8	0.4
2	R203	0.30	0.8	1.9	2.3	3.9	3.4
3	R340	0.25	1.5	2.3	3.5	1.3	0.3
4	R453	0.13	0.6	1.8	2.5	3.7	3.6

# Reshaping data

```
1 # Gather time columns [t0,...,t5] into rows
2 df = pd.melt(df,
3             id_vars="Sample",
4             var_name="Time",
5             value_name="Exprs")
```

	Sample	Time	Exprs
0	R100	t0	0.20
1	R201	t0	0.10
2	R203	t0	0.30
3	R340	t0	0.25
4	R453	t0	0.13
5	R100	t1	1.30
6	R201	t1	1.80
7	R203	t1	0.80
8	R340	t1	1.50
9	R453	t1	0.60
10	R100	t2	2.80
11	R201	t2	3.10
12	R203	t2	1.90
13	R340	t2	2.30
14	R453	t2	1.80
15	R100	t3	3.20
16	R201	t3	3.70
17	R203	t3	2.30
18	R340	t3	3.50
19	R453	t3	2.50
20	R100	t4	1.20
21	R201	t4	1.80
22	R203	t4	3.90
23	R340	t4	1.30
24	R453	t4	3.70
25	R100	t5	0.70
26	R201	t5	0.40
27	R203	t5	3.40
28	R340	t5	0.30
29	R453	t5	3.60

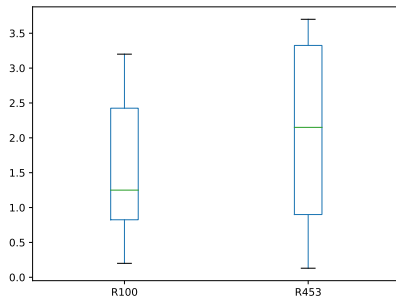
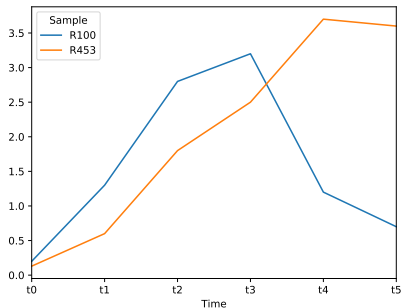
# Reshaping data

```
1 # Spread rows into columns [by time]
2 df = pd.pivot_table(df,
3                     values="Exprs",
4                     columns="Sample",
5                     index="Time")
```

Sample	R100	R201	R203	R340	R453
Time					
t0	0.2	0.1	0.3	0.25	0.13
t1	1.3	1.8	0.8	1.50	0.60
t2	2.8	3.1	1.9	2.30	1.80
t3	3.2	3.7	2.3	3.50	2.50
t4	1.2	1.8	3.9	1.30	3.70
t5	0.7	0.4	3.4	0.30	3.60

# Plot samples R100 and R453

```
1 # Time-plot
2 df.plot(y=["R100", "R453"])
3
4 # Box-plot
5 df.plot(y=["R100", "R453"], kind="box")
```





# Reading data files: Births per women

```
1 # Read data file
2 data = pd.read_csv("births_per_woman.csv", header=0)
3
4 # Explore what's in the data
5 data.head() # show first 5 rows of data
6 data.tail() # show last 5 rows of data
```

	CountryName	Region	IncomeGroup	1960	1961	\
0	Aruba	Latin America & Caribbean	High income	4.820	4.655	
1	Afghanistan	South Asia	Low income	7.450	7.450	
2	Angola	Sub-Saharan Africa	Upper middle income	7.379	7.388	
3	Albania	Europe & Central Asia	Upper middle income	6.489	6.401	
4	Andorra	Europe & Central Asia	High income	NaN	NaN	

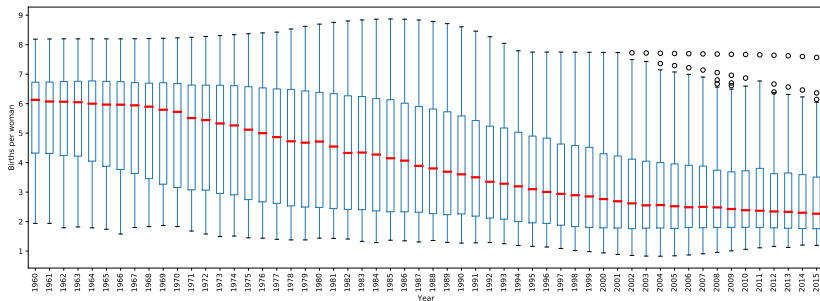
	1962	1963	1964	1965	1966	...	2006	2007	2008	2009	\
0	4.471	4.271	4.059	3.842	3.625	...	1.754	1.741	1.728	1.716	
1	7.450	7.450	7.450	7.450	7.450	...	6.639	6.437	6.218	5.985	
2	7.396	7.402	7.406	7.408	7.406	...	6.671	6.619	6.559	6.492	
3	6.282	6.133	5.960	5.773	5.581	...	1.668	1.635	1.625	1.636	
4	NaN	NaN	NaN	NaN	NaN	...	1.240	1.180	1.250	1.190	

	2010	2011	2012	2013	2014	2015
0	1.704	1.692	1.680	1.669	1.657	1.647
1	5.746	5.506	5.272	5.050	4.843	4.653
2	6.416	6.335	6.251	6.165	6.080	5.996
3	1.663	1.699	1.735	1.765	1.784	1.793
4	1.270	NaN	NaN	NaN	NaN	NaN

# Descriptive statistics

```
1 # Median births per woman 1970 vs 1990 vs 2010
2 data["1970"].median() # 5.7 births per woman
3 data["1990"].median() # 3.6 births per woman
4 data["2010"].median() # 2.4 births per woman
5
6 # Box plot
7 data.plot(kind="box", rot=90, color={"medians": "red"},
8         medianprops={"linewidth": 3})
```



# Reshaping data

```
1 # Gather year columns into rows
2 df = pd.melt(data,
3             id_vars = ["CountryName", "Region", "
4                       IncomeGroup"],
5             var_name="Year",
6             value_name="Birth")
```

	CountryName	Region	IncomeGroup	Year	Birth
0	Aruba	Latin America & Caribbean	High income	1960	4.820
1	Afghanistan	South Asia	Low income	1960	7.450
2	Angola	Sub-Saharan Africa	Upper middle income	1960	7.379
3	Albania	Europe & Central Asia	Upper middle income	1960	6.489
4	Andorra	Europe & Central Asia	High income	1960	NaN

# Reshaping data

```
1 # Spread rows into columns
2 df = pd.pivot_table(df, values="Birth", columns="CountryName",
    index="Year")
```

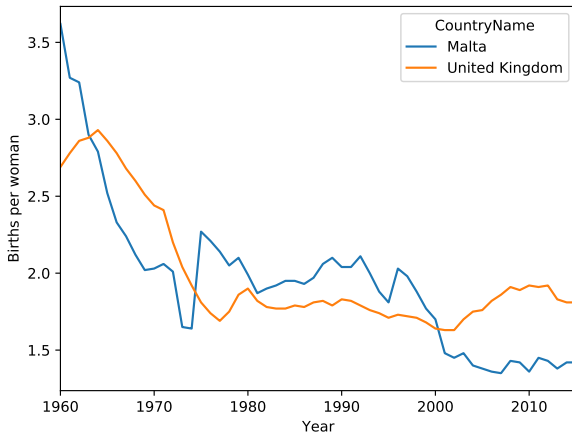
CountryName	Afghanistan	Albania	Algeria	American Samoa	Andorra	Angola	\
Year							
1960	7.45	6.489	7.524	NaN	NaN	7.379	
1961	7.45	6.401	7.573	NaN	NaN	7.388	
1962	7.45	6.282	7.614	NaN	NaN	7.396	
1963	7.45	6.133	7.646	NaN	NaN	7.402	
1964	7.45	5.960	7.665	NaN	NaN	7.406	

CountryName	Antigua and Barbuda	Arab World	Argentina	Armenia	...	\
Year					...	
1960		4.425	6.919764	3.109	4.550	...
1961		4.386	6.941085	3.100	4.512	...
1962		4.344	6.958855	3.089	4.435	...
1963		4.299	6.970768	3.078	4.317	...
1964		4.250	6.974893	3.068	4.161	...

CountryName	Zambia	Zimbabwe
Year		
1960	7.018	7.158
1961	7.071	7.215
1962	7.127	7.267
1963	7.184	7.311
1964	7.240	7.347

# Compare birth rates

```
1 # Compare Malta vs United Kingdom
2 df.plot(y=["Malta", "United Kingdom"])
```



# Try yourself with pandas

- Change data with `pandas.apply()`