# pandas

$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$

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# Pandas

- Powerful and productive Python data analysis and management library
- **Pan**el **Da**ta **S**ystem
- Open Sourced by AQR Capital Management, LLC in late 2009
- 30.000 lines of tested Python/Cython code
- Used in production in many companies

# Pandas

- Rich data structures and functions to make working with structured data fast, easy, and expressive
- Built on top of Numpy with its high performance array-computing features
- flexible data manipulation capabilities of spreadsheets and relational databases
- Sophisticated indexing functionality
    - slice, dice, perform aggregations, select subsets of data

# The ideal tool for data scientists

- Cleaning data
- Analyzing data
- Modeling data
- Organizing the results of the analysis into a form suitable for plotting or tabular display

# Series

- one-dimensional array-like object

```
>>> s = Series((1,2,3,4,5))
```

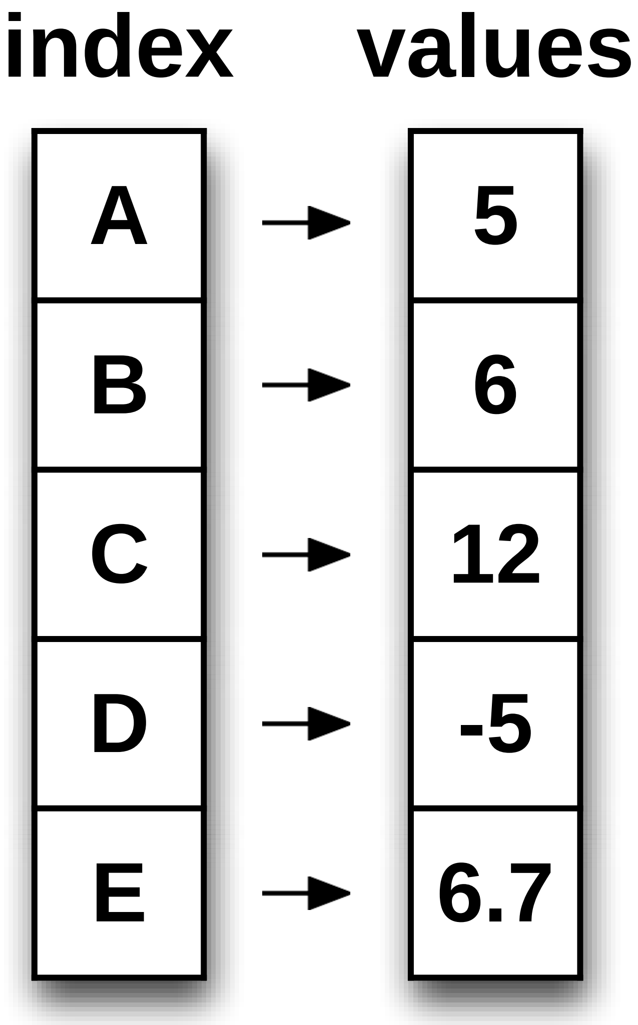
- Contains an array of data (of any Numpy data type)

```
>>> s.values
```

- Has an associated array of data labels, the *index* (Default index from 0 to N - 1)

```
>>> s.index
```

# Series



| index | values |
|---|---|
| A | 5 |
| B | 6 |
| C | 12 |
| D | -5 |
| E | 6.7 |

- Subclass of `numpy.ndarray`
- Data: any type
- Index labels need not be ordered
- Duplicates are possible (but result in reduced functionality)

# Series data structure

```
  >>>  import numpy
>>>  randn    = numpy.random.randn
>>>  from pandas import *
>>>  s  =  Series(randn(3),('a','b','c'))
>>>  s
a      -0.889880
b        1.102135
c      -2.187296
>>>  s.mean()
-0.65834710697853194
```

# Series to/from dict

- Series to Python dict - **No more explicit order**

```
>>> dict(s)
{'a':     -0.88988001423312313,
  'c':    -2.1872960440695666,
  'b':     1.1021347373670938}
```

- Back to a Series with a **new Index from sorted dictionary keys**

```
>>> Series(dict(s))
a     -0.889880
b      1.102135
c     -2.187296
```

# Reindexing labels

```
>>>  s
a     -0.496848
b       0.607173
c     -1.570596
>>>  s.index
Index([a, b, c],     dtype=object)
>>>  s.reindex(['c','b','a'])
c     -1.570596
b       0.607173
a     -0.496848
```

# Vectorization

```
>>> s + s
a    -1.779760
b     2.204269
c    -4.374592
```

- Series work with Numpy

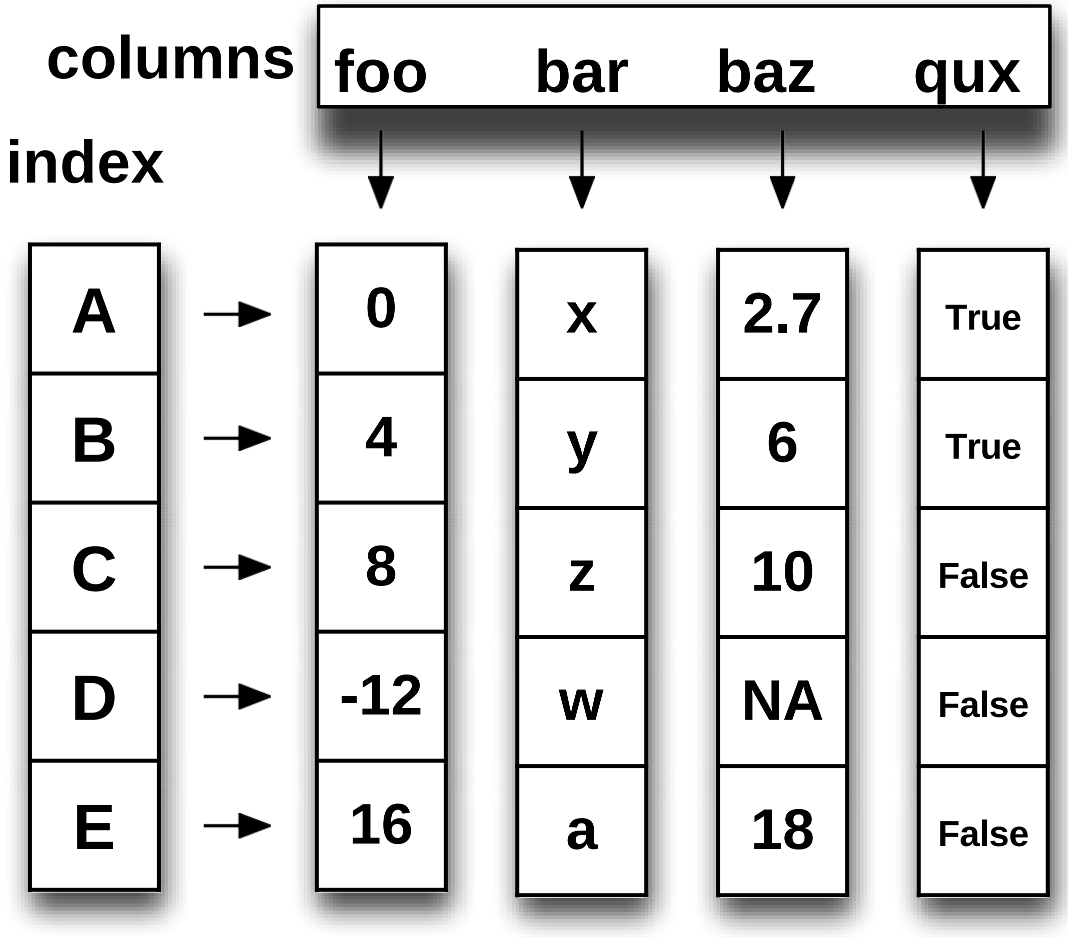
```
>>> numpy.exp(s)

a     0.410705
b     3.010586
c     0.112220
```

# DataFrame

- Like data.frame in the statistical language/package R
- 2-dimensional tabular data structure
- Data manipulation with integrated indexing
- Support heterogeneous columns
- Homogeneous columns

# DataFrame



columns

index

| index | foo | bar | baz | qux |
|---|---|---|---|---|
| A | 0 | x | 2.7 | True |
| B | 4 | y | 6 | True |
| C | 8 | z | 10 | False |
| D | -12 | w | NA | False |
| E | 16 | a | 18 | False |

- NumPy array-like
- Each column can have a different type
- Row and column index
- Size mutable: insert and delete columns

# DataFrame

```
>>> d = {'one': s*s, 'two': s+s}
>>> DataFrame(d)
          one        two
a    0.791886  -1.779760
b    1.214701   2.204269
c    4.784264  -4.374592
>>> df.index
Index([a, b, c], dtype=object)
>>> df.columns
Index([one, two], dtype=objec)
```

# Dataframe add column

- Add a third column

```
>>> df['three']        = s * 3
```

- It will share the existing index

```
>>> df
        one        two       three
a  0.791886  -1.779760  -2.669640
b  1.214701   2.204269   3.306404
c  4.784264  -4.374592  -6.561888
```

# Access to columns

- Access by attribute

```
>>> df.one
         one
a  0.791886
b  1.214701
c  4.784264
```

- Access by dict like notation

```
>>> df['one']
         one
a  0.791886
b  1.214701
c  4.784264
```

# Reindexing

```
>>>  df.reindex(['c','b','a'])
>>>  df
          one        two      three
c    4.784264  -4.374592  -6.561888
b    1.214701   2.204269   3.306404
a    0.791886  -1.779760  -2.669640
```

# Drop entries from an axis

```
>>>  df.drop('c')

b  1.214701     2.204269     3.306404
a  0.791886    -1.779760    -2.669640

>>>  df.drop(['b,'a'])

          one          two          three
c  4.784264    -4.374592    -6.561888
```

# Descriptive statistics

```
>>>  df.mean()
one          2.263617
two         -1.316694
three       -1.975041
```

- Also: count, sum, median, min, max, abs, prod, std, var, skew, kurt, quantile, cumsum, cumprod, cummax, cummin

# Computational Tools

- Covariance

```
>>> s1 = Series(randn(1000))
>>> s2 = Series(randn(1000))
>>> s1.cov(s2)
0.013973709323221539
```

- Also: pearson, kendall,spearman

# I/O Operations

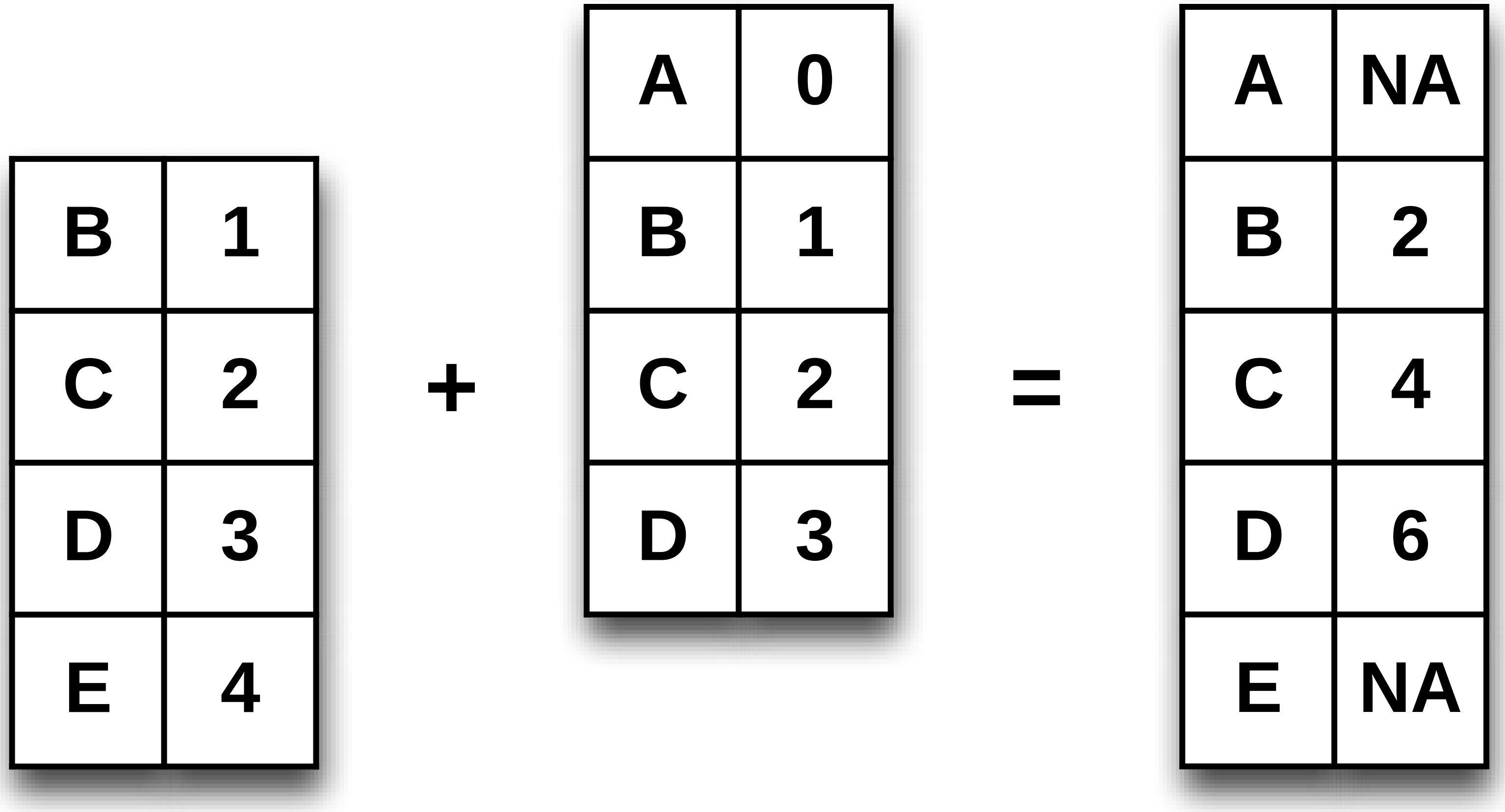
Read from

- csv, json, excel, html, SQL…

- https://pandas.pydata.org/pandas-docs/stable/generated/pandas.read_csv.html#pandas.read_csv

# Data alignment

- Binary operations are joins!
- https://pandas.pydata.org/pandas-docs/stable/generated/pandas.Series.align.html#pandas.Series.align



| | |
|---|---|
| B | 1 |
| C | 2 |
| D | 3 |
| E | 4 |

+

| | |
|---|---|
| A | 0 |
| B | 1 |
| C | 2 |
| D | 3 |

=

| | |
|---|---|
| A | NA |
| B | 2 |
| C | 4 |
| D | 6 |
| E | NA |

# Data manipulations

- Join / merge – database-like syntax
- Get_dummies (one hot vector from categorical data)

# Aggregated Statistics

- Group by
- Describe

# Plotting

DataFrame.plot.plotType()

- hist, pie, density, box,…

# This and much more...

- Group by: split-apply-combine
- Merge, join and aggregate
- Reshaping and Pivot Tables
- Time Series / Date functionality
- Plotting with matplotlib
- IO Tools (Text, CSV, HDF5, ...)
- Sparse data structures

# Resources

- http://pypi.python.org/pypi/pandas
- http://code.google.com/p/pandas