UFRN UNIVERSIDADE FEDERAL DO RIO GRANDE DO NORTE

IMD INSTITUTO METRÓPOLE DIGITAL

Data Science & ML Course

Lesson #4 [Part #2] Introduction to Pandas

Ivanovitch Silva

October, 2018

Agenda

- About the two core pandas types: **dataframes** and **series**
- How to **select** data using row and column labels
- A variety of methods for **exploring data** with pandas
- How to **assign** data using various techniques in pandas
- How to use **boolean indexing** with pandas for selection and assignment

Update from repository

```
git clone https://github.com/ivanovitchm/datascience2machinelearning.git
```

Or ….

```
git pull
```

Understanding Pandas & Numpy

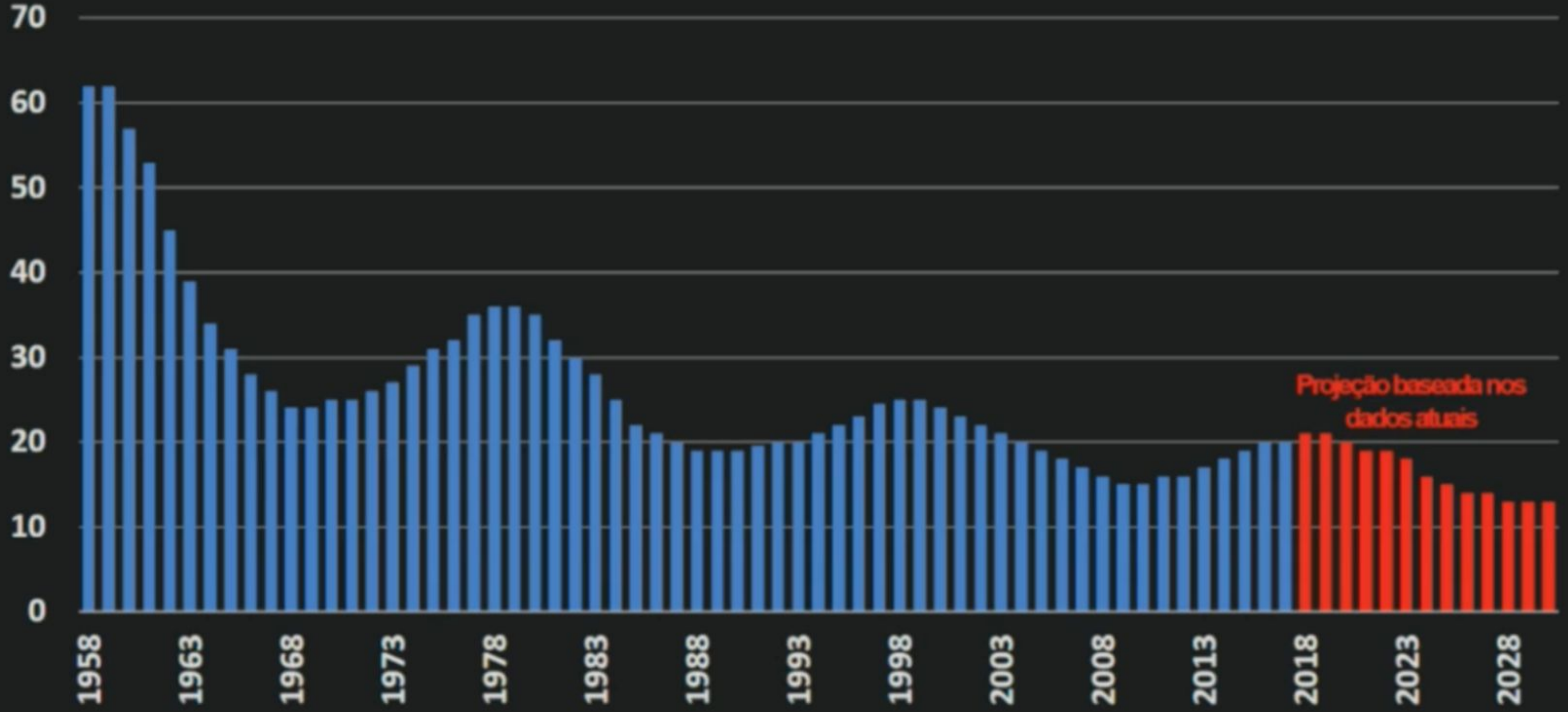
- Numpy
  1. Lack support for column names
  2. Support for only one data type per ndarray
  3. There are lots of low level methods, however there are many common analysis patterns that don't have pre-built methods.

The pandas library provides solutions to all of these pain points and more. Pandas is not so much a replacement for NumPy as an extension of NumPy.

THE WORLD'S LARGEST CORPORATIONS
FORTUNE
GLOBAL
500

Tempo médio de permanência de uma empresa no S&P 500

(em anos)

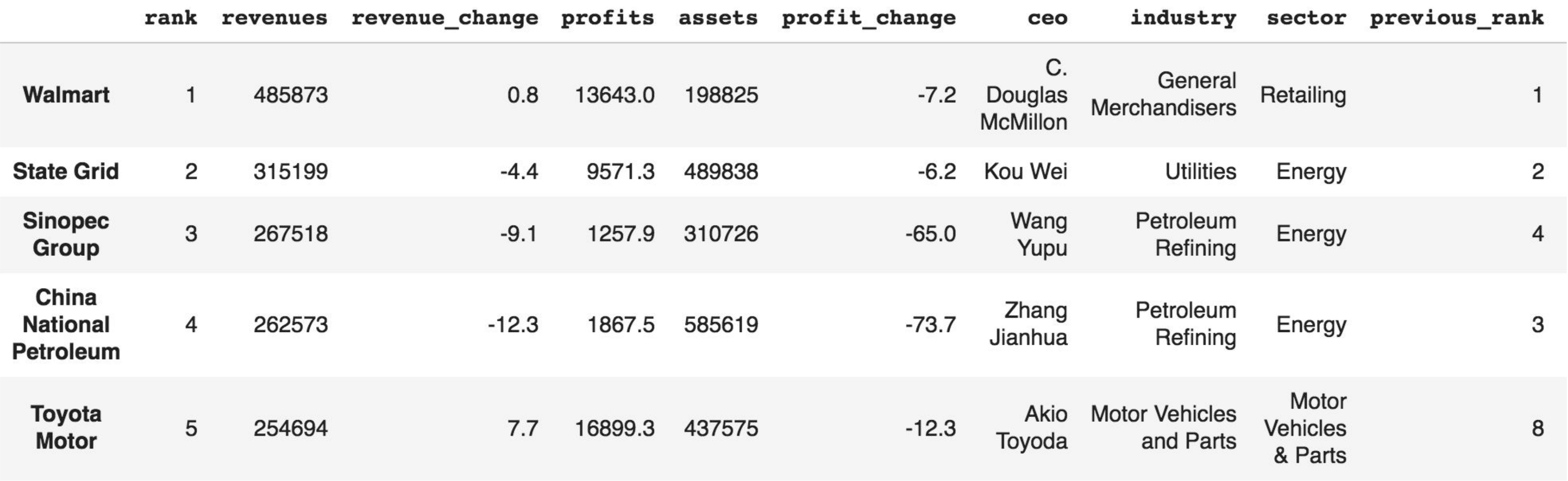


Fonte: INNOSIGHT, Richard N. Foster, Standard & Poor's

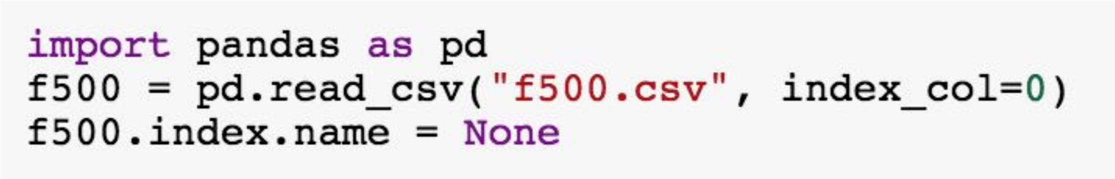
UMA EMPRESA DO S&P 500 ESTÁ SENDO SUBSTITUÍDA A CADA DUAS SEMANAS

Richard Foster

The dataset

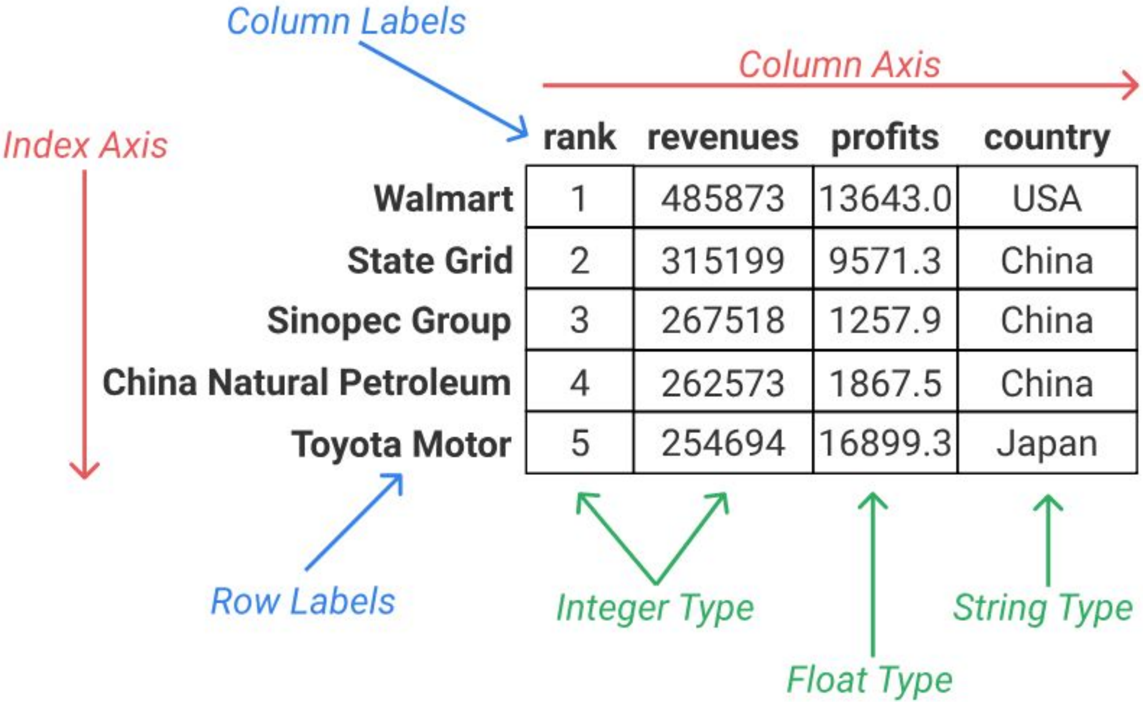


	rank	revenues	revenue_change	profits	assets	profit_change	ceo	industry	sector	previous_rank
Walmart	1	485873	0.8	13643.0	198825	-7.2	C. Douglas McMillon	General Merchandisers	Retailing	1
State Grid	2	315199	-4.4	9571.3	489838	-6.2	Kou Wei	Utilities	Energy	2
Sinopec Group	3	267518	-9.1	1257.9	310726	-65.0	Wang Yupu	Petroleum Refining	Energy	4
China National Petroleum	4	262573	-12.3	1867.5	585619	-73.7	Zhang Jianhua	Petroleum Refining	Energy	3
Toyota Motor	5	254694	7.7	16899.3	437575	-12.3	Akio Toyoda	Motor Vehicles and Parts	Motor Vehicles & Parts	8



```
import pandas as pd
f500 = pd.read_csv("f500.csv", index_col=0)
f500.index.name = None
```

Introducing Dataframes



Column Labels

Column Axis

Index Axis

	rank	revenues	profits	country
Walmart	1	485873	13643.0	USA
State Grid	2	315199	9571.3	China
Sinopec Group	3	267518	1257.9	China
China Natural Petroleum	4	262573	1867.5	China
Toyota Motor	5	254694	16899.3	Japan

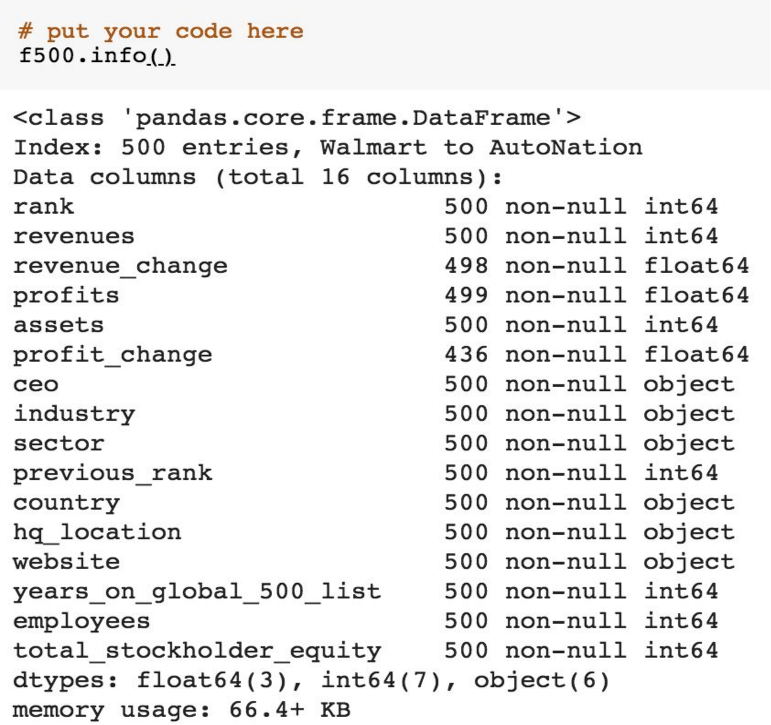
Row Labels

Integer Type

Float Type

String Type

Introducing Dataframes



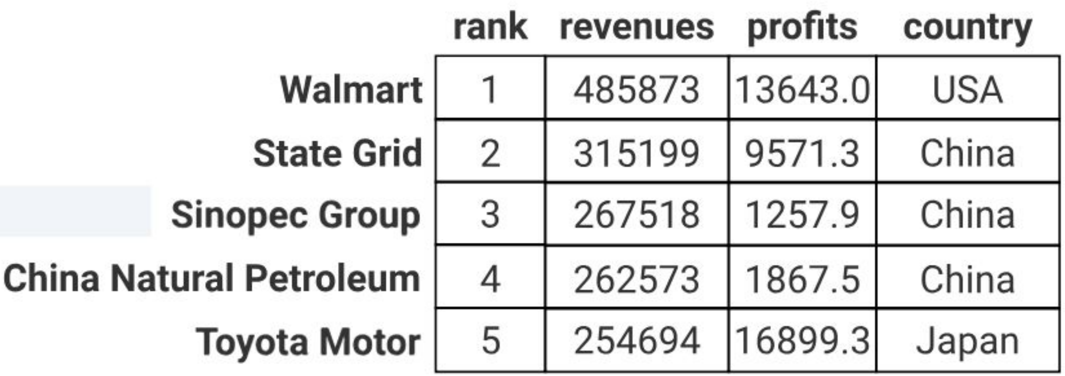
```
# put your code here
f500.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 500 entries, Walmart to AutoNation
Data columns (total 16 columns):
rank                        500 non-null int64
revenues                    500 non-null int64
revenue_change              498 non-null float64
profits                     499 non-null float64
assets                      500 non-null int64
profit_change               436 non-null float64
ceo                         500 non-null object
industry                    500 non-null object
sector                      500 non-null object
previous_rank               500 non-null int64
country                     500 non-null object
hq_location                 500 non-null object
website                     500 non-null object
years_on_global_500_list    500 non-null int64
employees                   500 non-null int64
total_stockholder_equity    500 non-null int64
dtypes: float64(3), int64(7), object(6)
memory usage: 66.4+ KB
```

f500.head()
f500.tail()

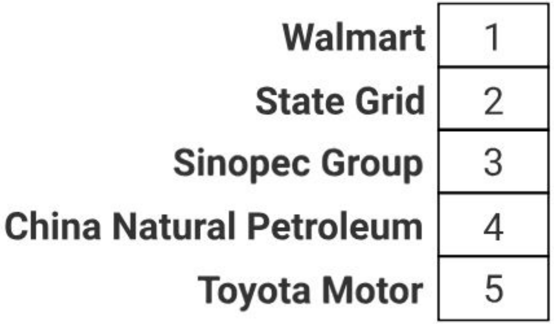
Selecting Columns From a Dataframe by label

```
f500_selection
```



	rank	revenues	profits	country
Walmart	1	485873	13643.0	USA
State Grid	2	315199	9571.3	China
Sinopec Group	3	267518	1257.9	China
China Natural Petroleum	4	262573	1867.5	China
Toyota Motor	5	254694	16899.3	Japan

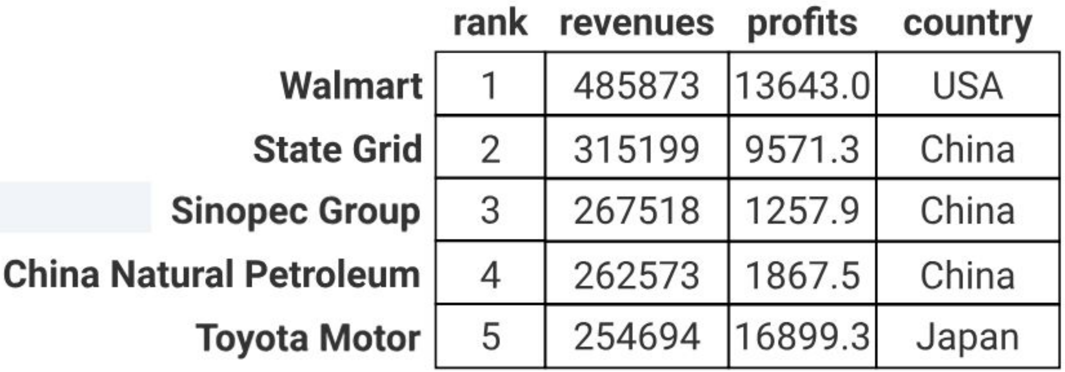
```
f500_selection.loc[:,"rank"]
```



Walmart	1
State Grid	2
Sinopec Group	3
China Natural Petroleum	4
Toyota Motor	5

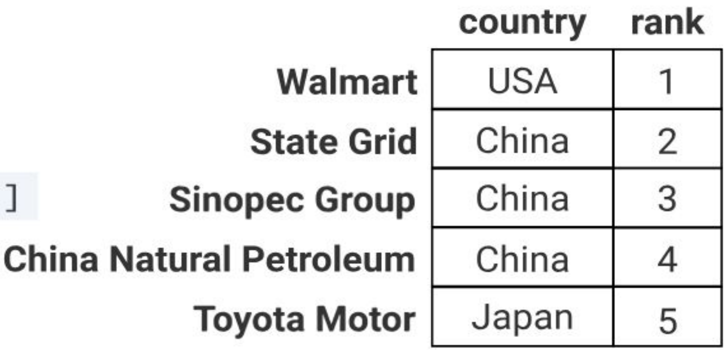
Selecting Columns From a Dataframe by label

```
f500_selection
```



	rank	revenues	profits	country
Walmart	1	485873	13643.0	USA
State Grid	2	315199	9571.3	China
Sinopec Group	3	267518	1257.9	China
China Natural Petroleum	4	262573	1867.5	China
Toyota Motor	5	254694	16899.3	Japan

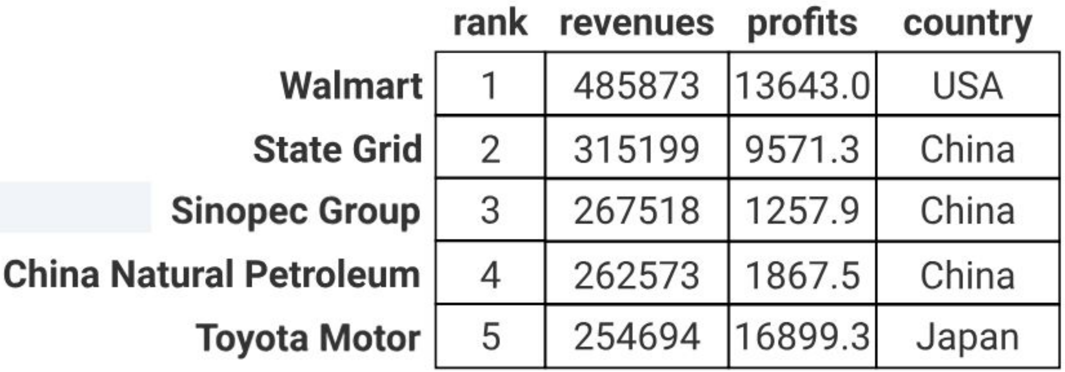
```
f500_selection.loc[:,["country","rank"]]
```



	country	rank
Walmart	USA	1
State Grid	China	2
Sinopec Group	China	3
China Natural Petroleum	China	4
Toyota Motor	Japan	5

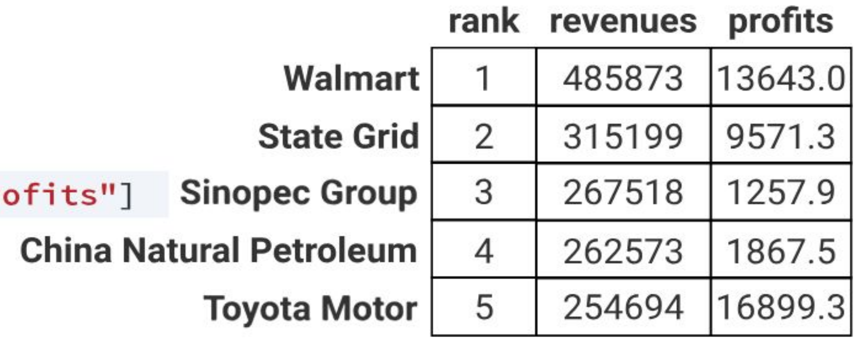
Selecting Columns From a Dataframe by label

```
f500_selection
```



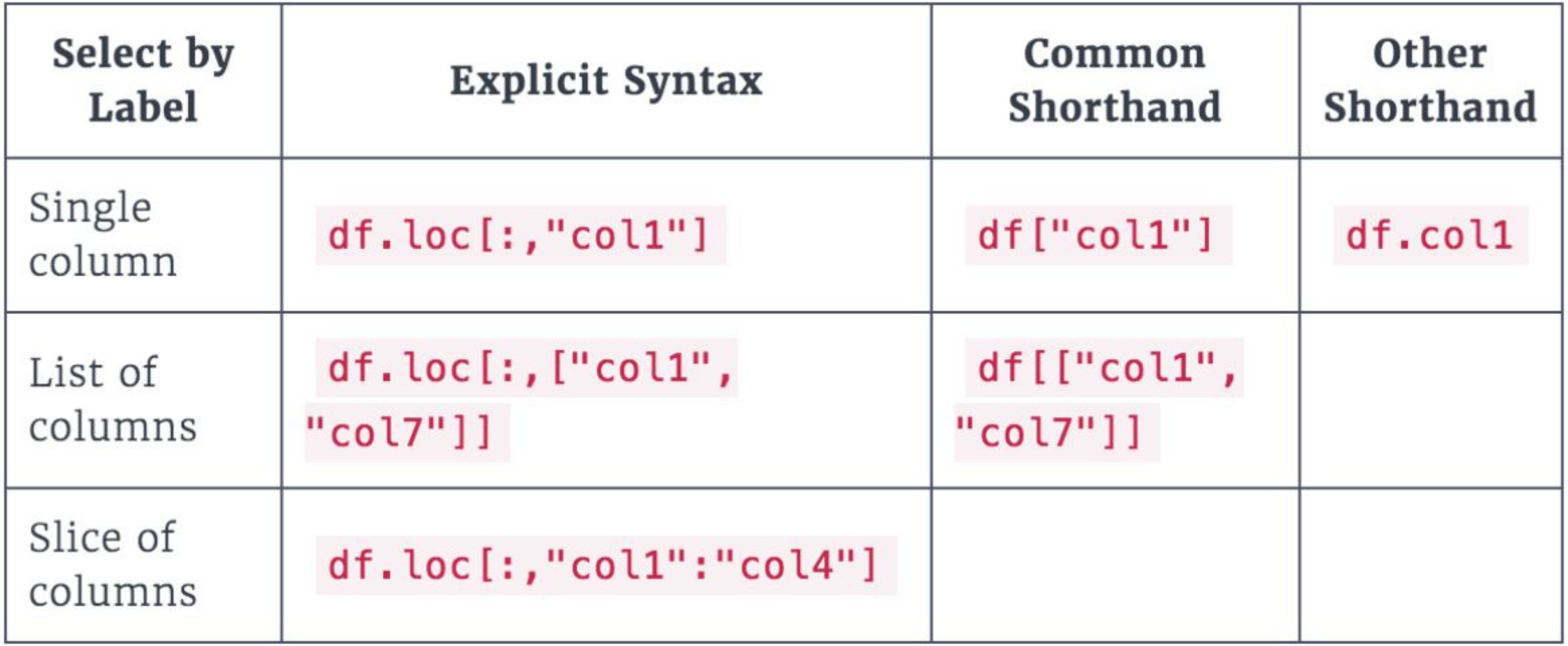
	rank	revenues	profits	country
Walmart	1	485873	13643.0	USA
State Grid	2	315199	9571.3	China
Sinopec Group	3	267518	1257.9	China
China Natural Petroleum	4	262573	1867.5	China
Toyota Motor	5	254694	16899.3	Japan

```
f500_selection.loc[:,"rank":"profits"]
```



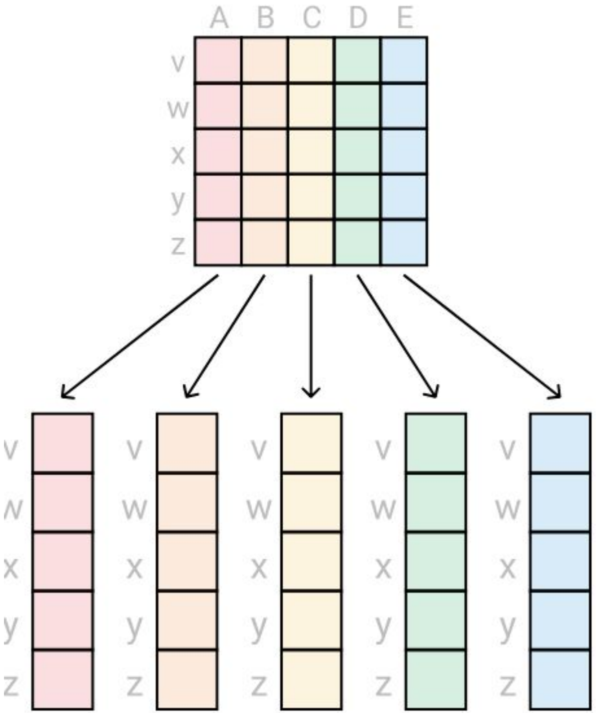
	rank	revenues	profits
Walmart	1	485873	13643.0
State Grid	2	315199	9571.3
Sinopec Group	3	267518	1257.9
China Natural Petroleum	4	262573	1867.5
Toyota Motor	5	254694	16899.3

Column selection shortcuts



Select by Label	Explicit Syntax	Common Shorthand	Other Shorthand
Single column	`df.loc[:,"col1"]`	`df["col1"]`	`df.col1`
List of columns	`df.loc[:,["col1", "col7"]]`	`df[["col1", "col7"]]`	
Slice of columns	`df.loc[:,"col1":"col4"]`		

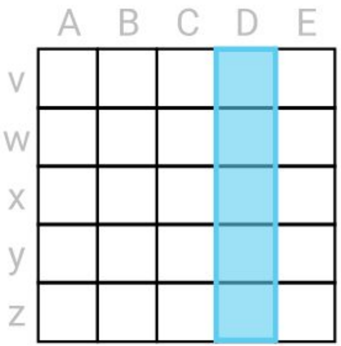
Selecting Items from a Series by Label



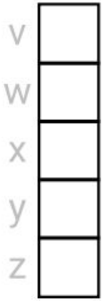
Original Dataframe

Code

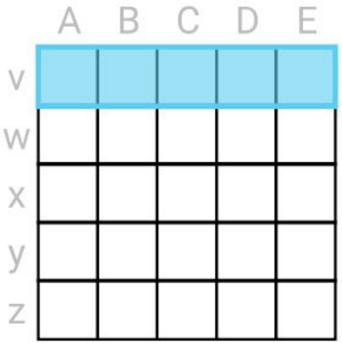
Result



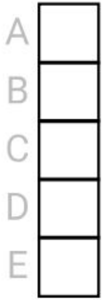
```
single_col = df["D"]
```



`single_col` is a series object



```
single_row = df.head(1)
```

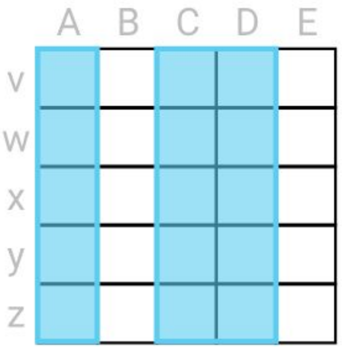


`single_row` is a series object

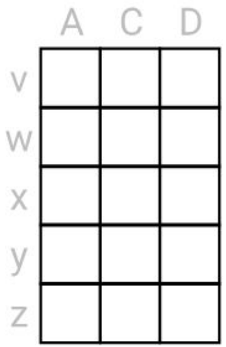
Original Dataframe

Code

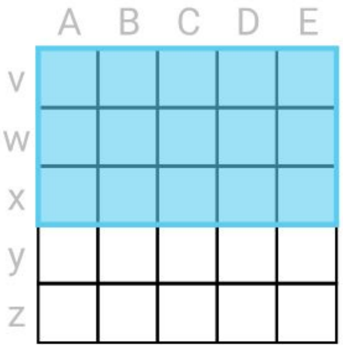
Result



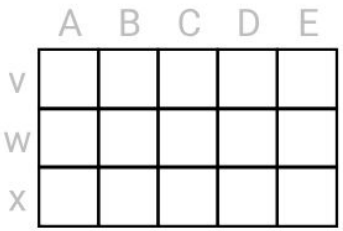
```
multi_cols = df[["A", "C", "D"]]
```



multi_cols is a dataframe object

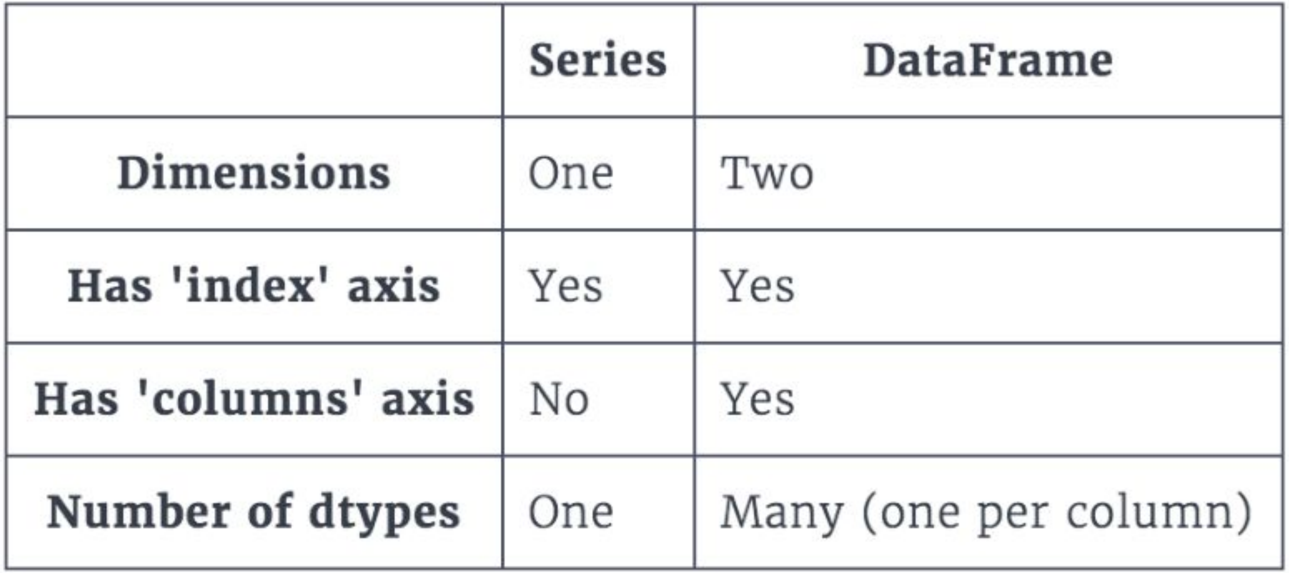


```
multi_rows = df.head(3)
```



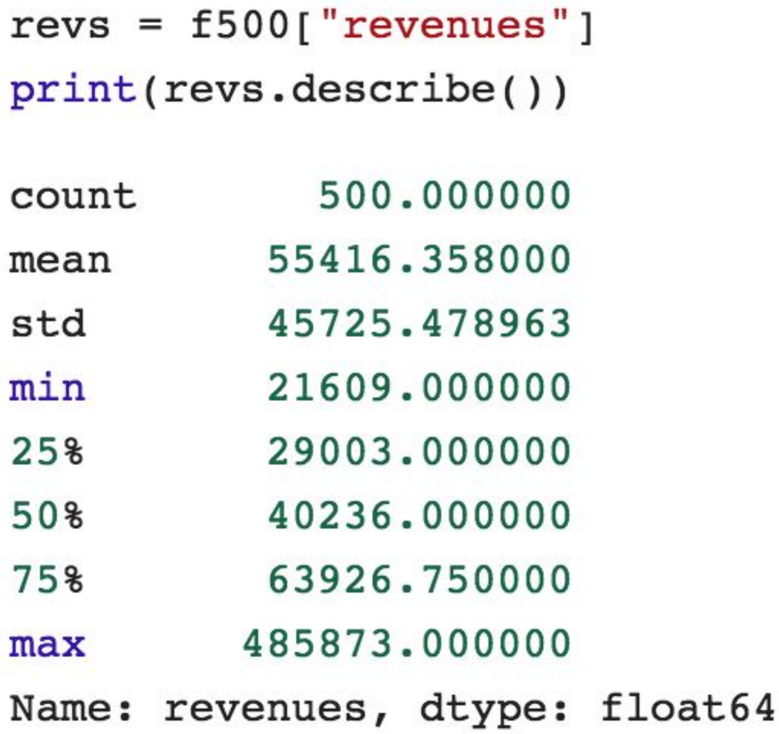
multi_rows is a dataframe object

Dataframe vs Series

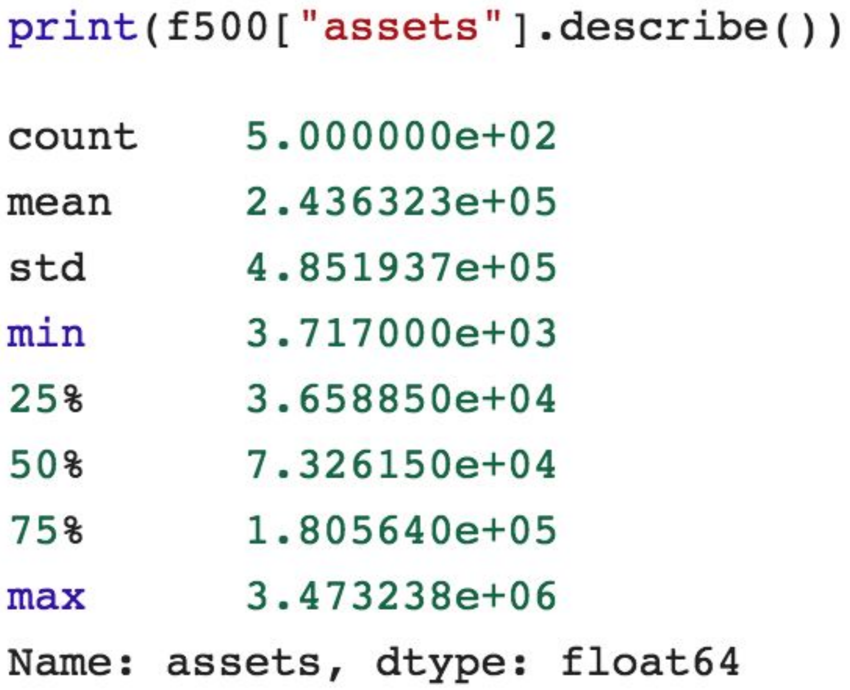


	Series	DataFrame
Dimensions	One	Two
Has 'index' axis	Yes	Yes
Has 'columns' axis	No	Yes
Number of dtypes	One	Many (one per column)

Series and Dataframe Describe Methods



```
revs = f500["revenues"]
print(revs.describe())

count       500.000000
mean      55416.358000
std       45725.478963
min       21609.000000
25%       29003.000000
50%       40236.000000
75%       63926.750000
max      485873.000000
Name: revenues, dtype: float64
```

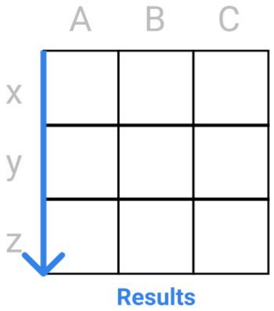


```
print(f500["assets"].describe())

count    5.000000e+02
mean     2.436323e+05
std      4.851937e+05
min      3.717000e+03
25%      3.658850e+04
50%      7.326150e+04
75%      1.805640e+05
max      3.473238e+06
Name: assets, dtype: float64
```

More data exploration methods

`DataFrame.method(axis=0)`
or
`DataFrame.method(axis="index")`

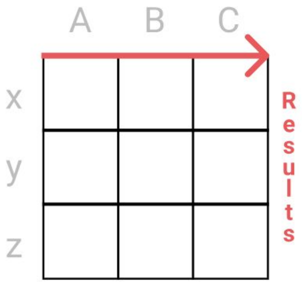
Calculates along the **row** axis



Calculates result for
each **column**.

`DataFrame.method(axis=1)`
or
`DataFrame.method(axis="column")`

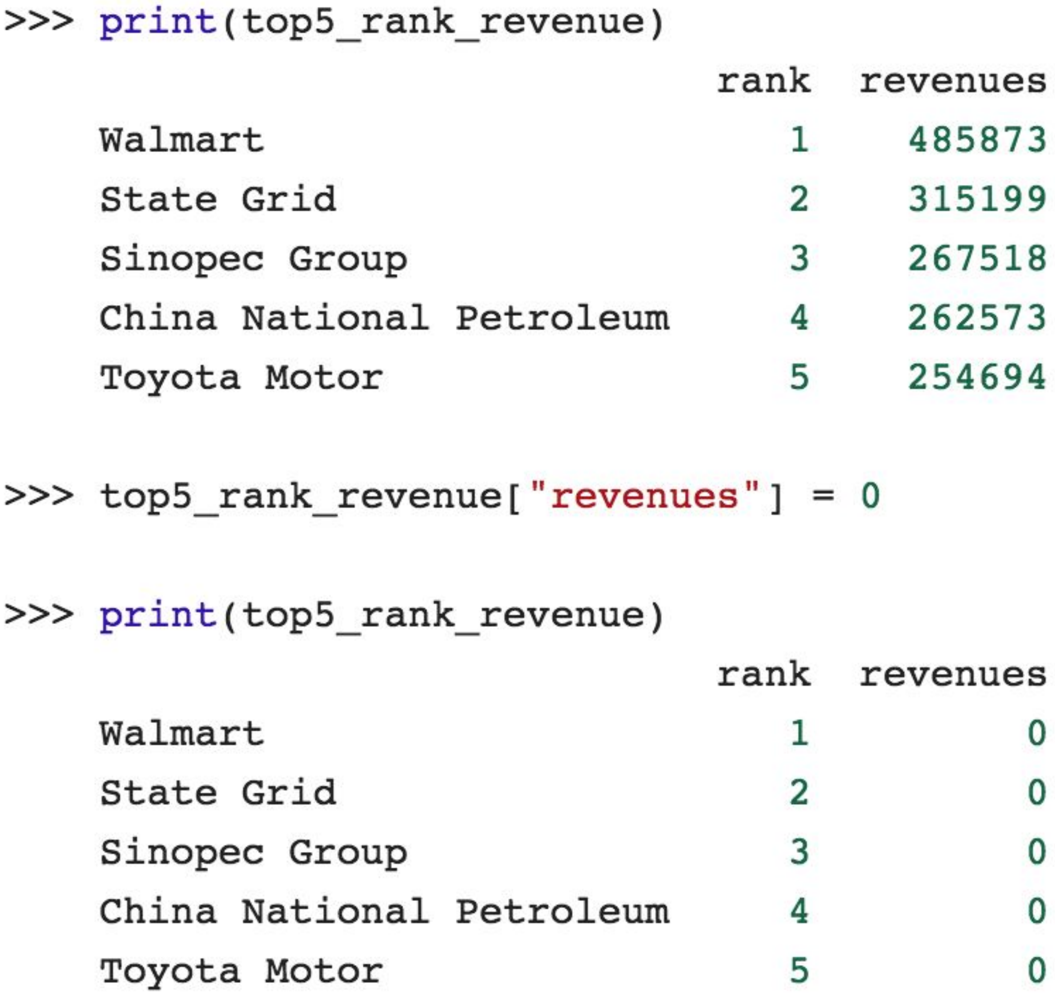
Calculates along the **column** axis



Calculates result for
each **row**.

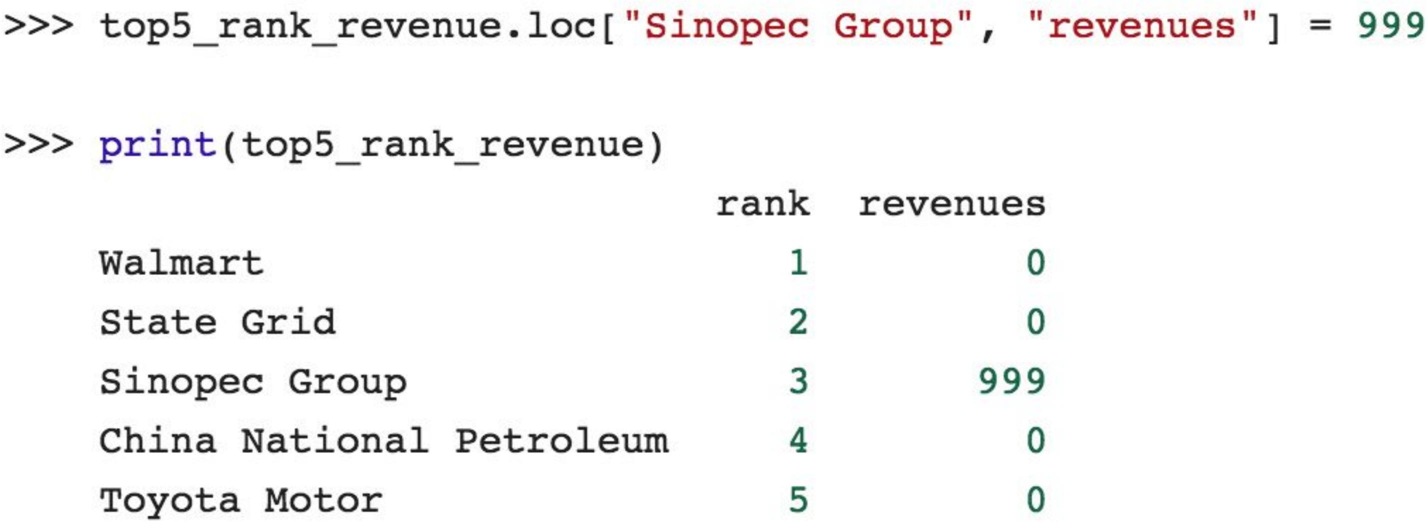
```
medians = f500[["revenues", "profits"]].median(axis=0)
# we could also use .median(axis="index")
print(medians)

revenues    40236.0
profits      1761.6
dtype: float64
```

Assignment with Pandas



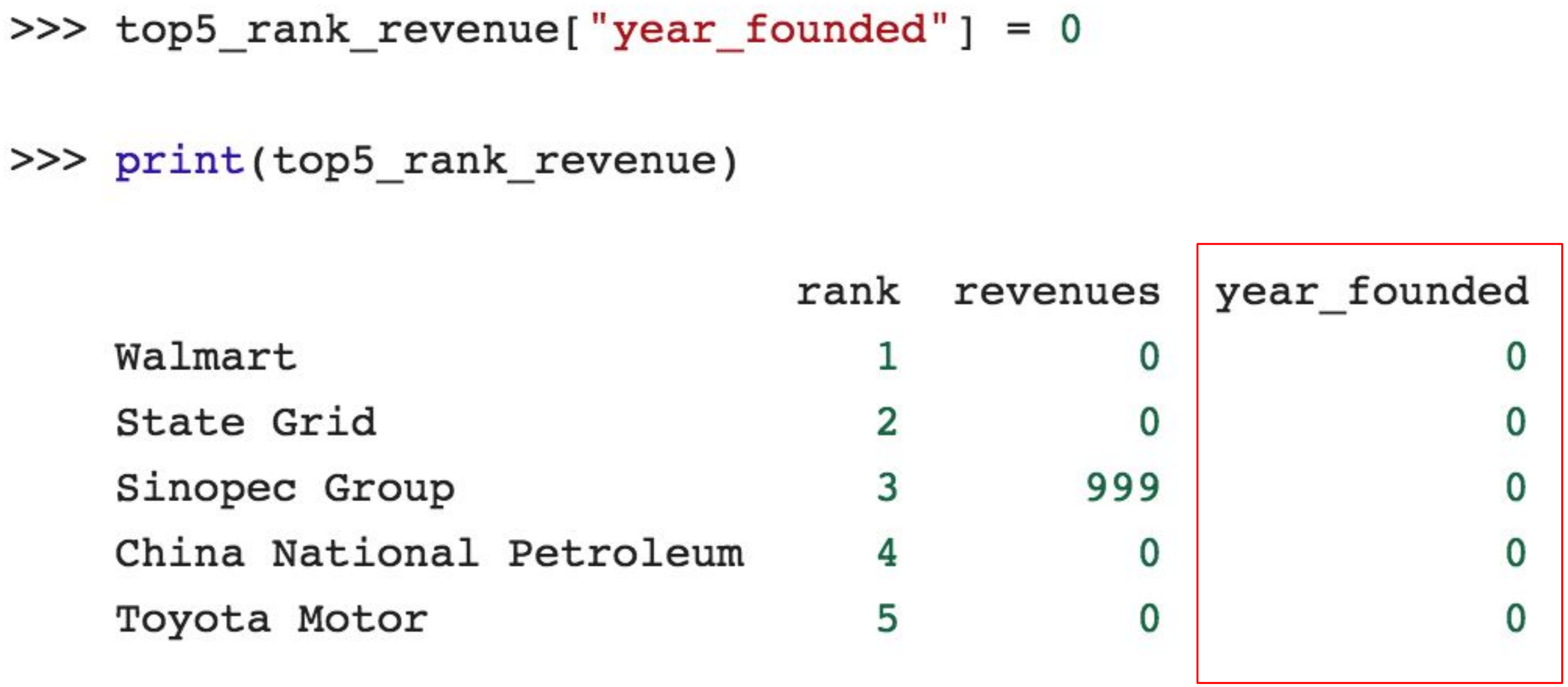
```
>>> print(top5_rank_revenue)
                              rank  revenues
    Walmart                      1    485873
    State Grid                   2    315199
    Sinopec Group                3    267518
    China National Petroleum     4    262573
    Toyota Motor                 5    254694

>>> top5_rank_revenue["revenues"] = 0

>>> print(top5_rank_revenue)
                              rank  revenues
    Walmart                      1         0
    State Grid                   2         0
    Sinopec Group                3         0
    China National Petroleum     4         0
    Toyota Motor                 5         0
```

Assignment with Pandas



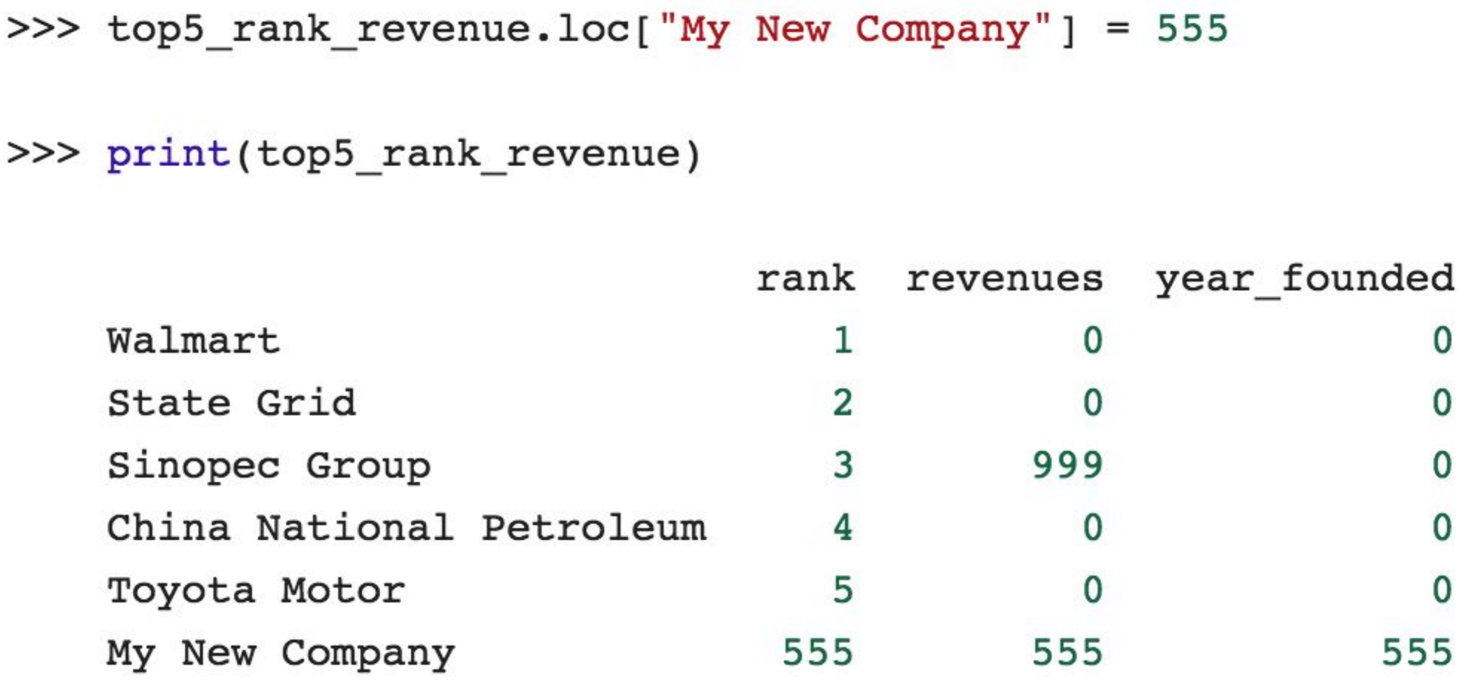
```
>>> top5_rank_revenue.loc["Sinopec Group", "revenues"] = 999

>>> print(top5_rank_revenue)
                              rank  revenues
    Walmart                      1         0
    State Grid                   2         0
    Sinopec Group                3       999
    China National Petroleum     4         0
    Toyota Motor                 5         0
```

Add a new column



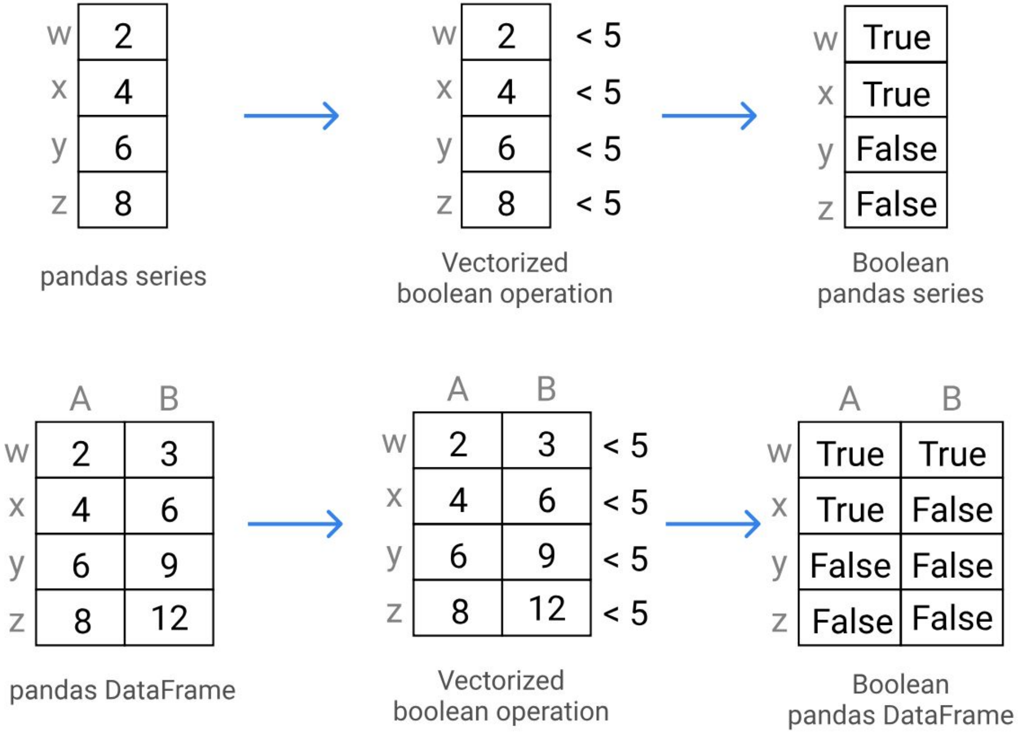
```
>>> top5_rank_revenue["year_founded"] = 0

>>> print(top5_rank_revenue)

                          rank  revenues  year_founded
    Walmart                  1         0             0
    State Grid               2         0             0
    Sinopec Group            3       999             0
    China National Petroleum 4         0             0
    Toyota Motor             5         0             0
```

Add a new row



```
>>> top5_rank_revenue.loc["My New Company"] = 555

>>> print(top5_rank_revenue)

                           rank  revenues  year_founded
Walmart                       1         0             0
State Grid                    2         0             0
Sinopec Group                 3       999             0
China National Petroleum      4         0             0
Toyota Motor                  5         0             0
My New Company              555       555           555
```

Using boolean indexing with pandas objects



w	2
x	4
y	6
z	8

pandas series

w	2	< 5
x	4	< 5
y	6	< 5
z	8	< 5

Vectorized boolean operation

w	True
x	True
y	False
z	False

Boolean pandas series

	A	B
w	2	3
x	4	6
y	6	9
z	8	12

pandas DataFrame

	A	B	
w	2	3	< 5
x	4	6	< 5
y	6	9	< 5
z	8	12	< 5

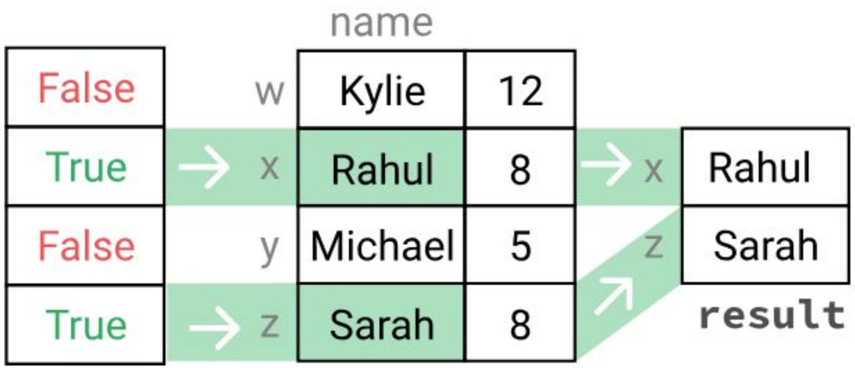
Vectorized boolean operation

	A	B
w	True	True
x	True	False
y	False	False
z	False	False

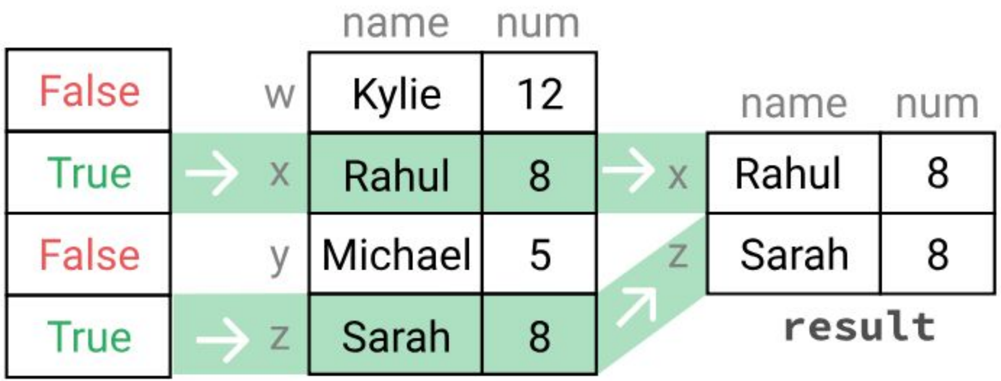
Boolean pandas DataFrame

Using boolean indexing with pandas objects

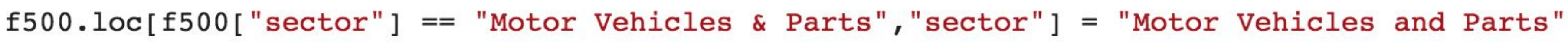
```
result = df.loc[num_bool, “name”]
```



```
result = df[num_bool]
```



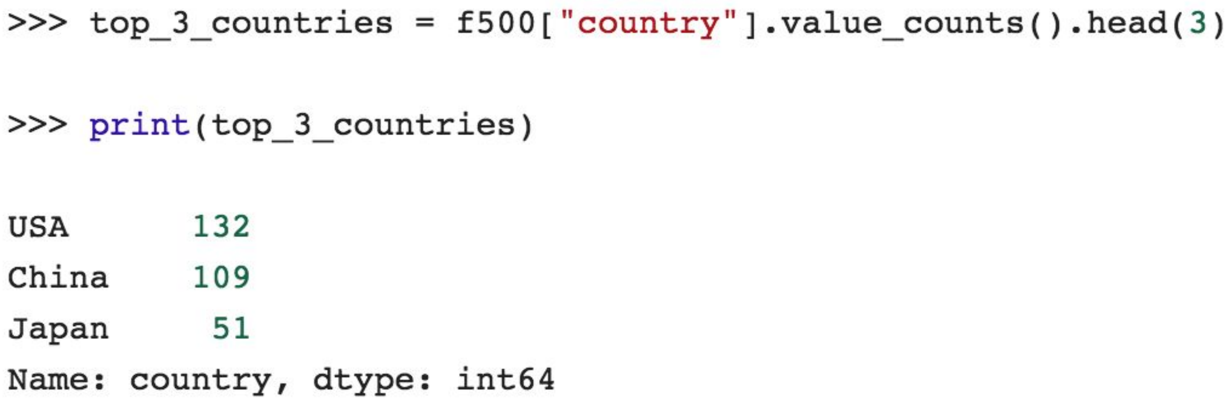
Using boolean arrays to assign values



```
f500.loc[f500["sector"] == "Motor Vehicles & Parts","sector"] = "Motor Vehicles and Parts"
```

Challenge

Finding top performers by country



```
>>> top_3_countries = f500["country"].value_counts().head(3)

>>> print(top_3_countries)

USA        132
China      109
Japan       51
Name: country, dtype: int64
```

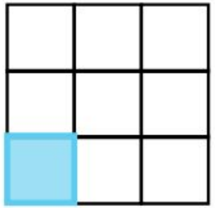
Lesson_04 Part #2
Section 1.12

Exploring Data With Pandas

Agenda

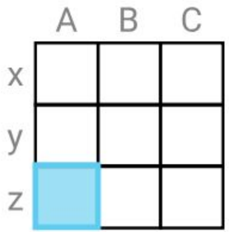
- Select columns, rows and individual items using their integer location.
- Work with integer axis labels.
- How to use pandas methods to produce boolean arrays.
- Use boolean operators to combine boolean comparisons to perform more complex analysis.
- Use index labels to align data.
- Use aggregation to perform advanced analysis using loops.

Introduction (Pandas vs Numpy)



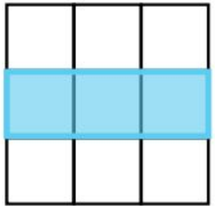
```
ndarray[2,0]
```

located at row **2***, column* **0**



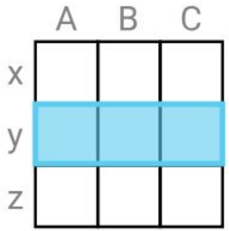
```
df.loc["z","A"]
```

located at row with label **z***, column with label* **A**



```
ndarray[1]
```

located at row **1**



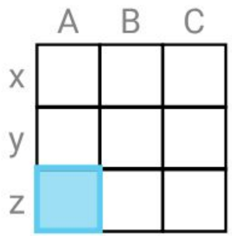
```
df.loc["y"]
```

located at row with label **y**

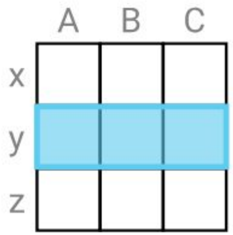
Numpy

Pandas

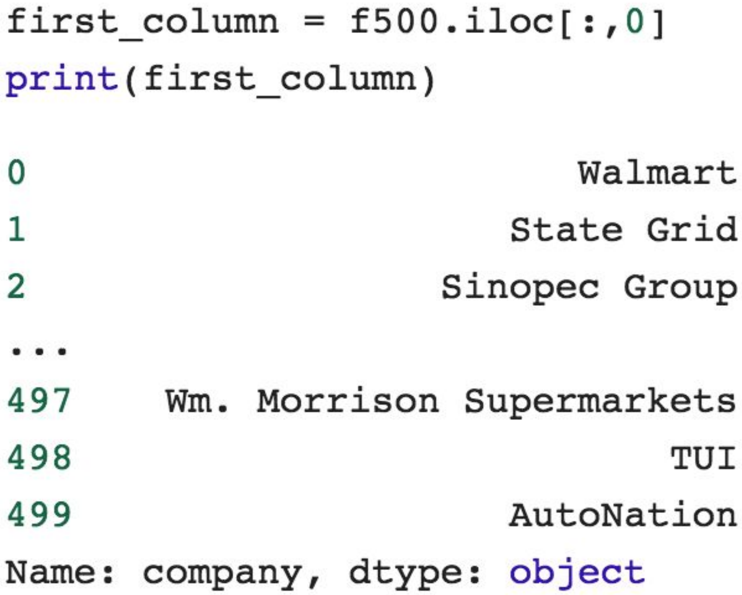
Using iloc to select by integer position



```
df.iloc[2,0]
```



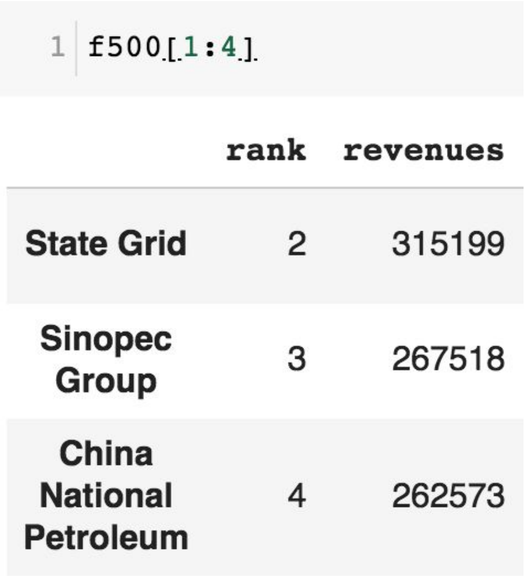
```
df.iloc[1]
```



```
first_column = f500.iloc[:,0]
print(first_column)

0                            Walmart
1                         State Grid
2                      Sinopec Group
...
497     Wm. Morrison Supermarkets
498                              TUI
499                       AutoNation
Name: company, dtype: object
```

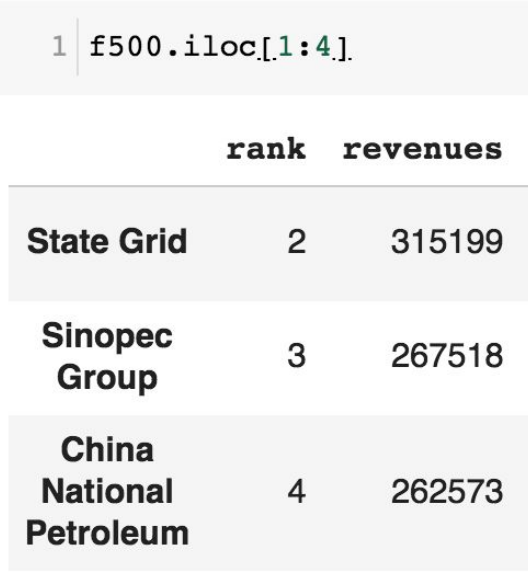
Slicing with iloc

With **loc[]**, the ending slice is **included**.
With **iloc[],** the ending slice is **not included**.



```
f500[1:4]
```

	rank	revenues
State Grid	2	315199
Sinopec Group	3	267518
China National Petroleum	4	262573



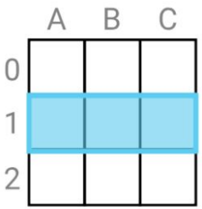
```
f500.iloc[1:4]
```

	rank	revenues
State Grid	2	315199
Sinopec Group	3	267518
China National Petroleum	4	262573

Loc vs iLoc

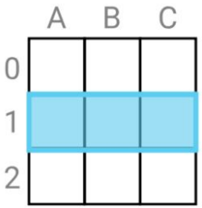
`df.iloc[1]`

`iloc[1]` *uses the integer position of the row to select the second row*



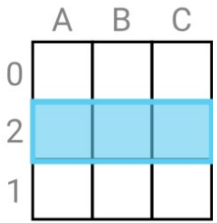
`df.loc[1]`

`loc[1]` *uses the label of the row to select the row with an axis label of* `1`.



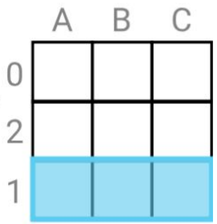
`df.iloc[1]`

`iloc[1]` *uses the integer position of the row to select the second row*

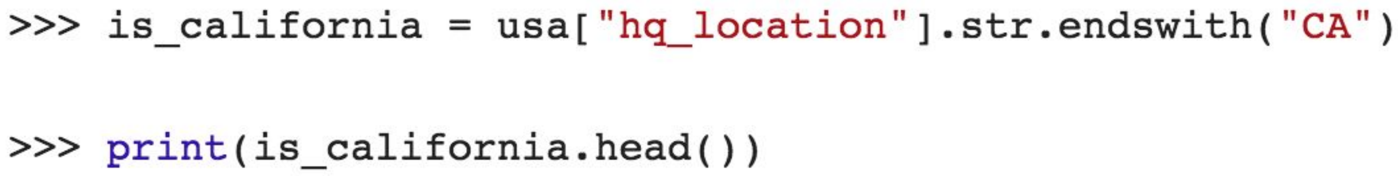


`df.loc[1]`

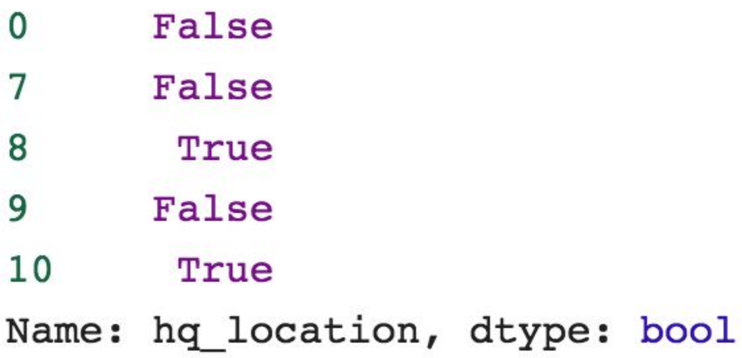
`loc[1]` *uses the label of the row to select the row with an axis label of* `1`.



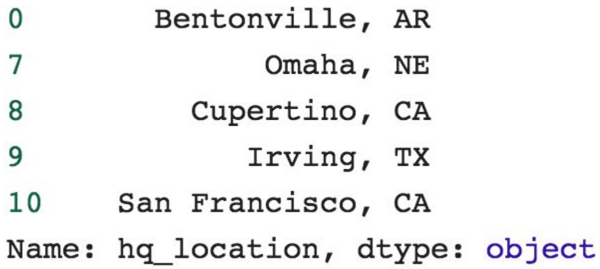
Using pandas methods to create boolean masks



```
>>> is_california = usa["hq_location"].str.endswith("CA")

>>> print(is_california.head())
```

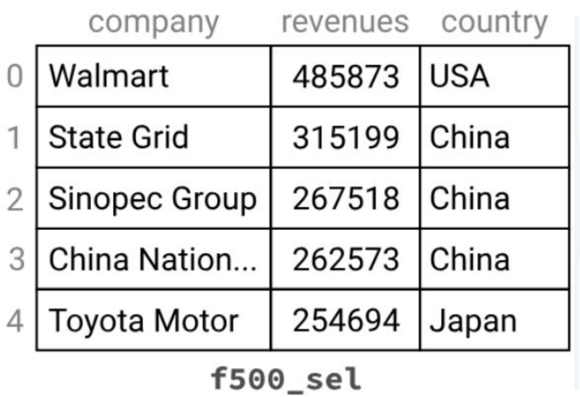


```
0       False
7       False
8        True
9       False
10       True
Name: hq_location, dtype: bool
```



```
0        Bentonville, AR
7              Omaha, NE
8          Cupertino, CA
9             Irving, TX
10     San Francisco, CA
Name: hq_location, dtype: object
```

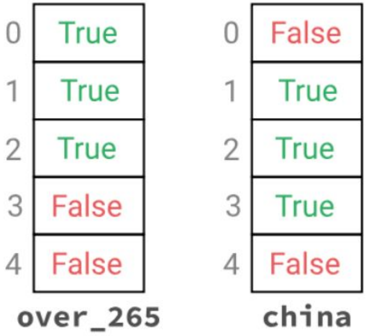
Using boolean operators to select items



	company	revenues	country
0	Walmart	485873	USA
1	State Grid	315199	China
2	Sinopec Group	267518	China
3	China Nation...	262573	China
4	Toyota Motor	254694	Japan

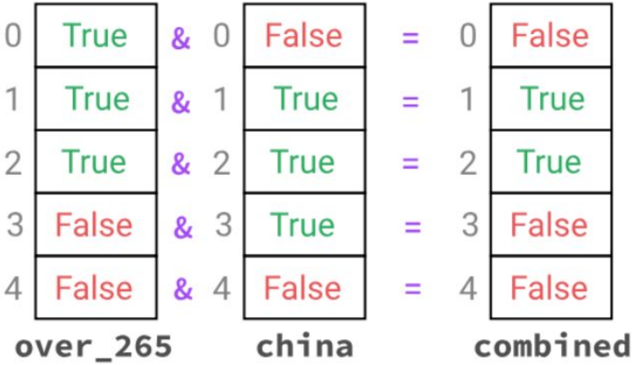
f500_sel

```
over_265 = f500_sel["revenues"] > 265000
china = f500_sel["country"] == "China"
```



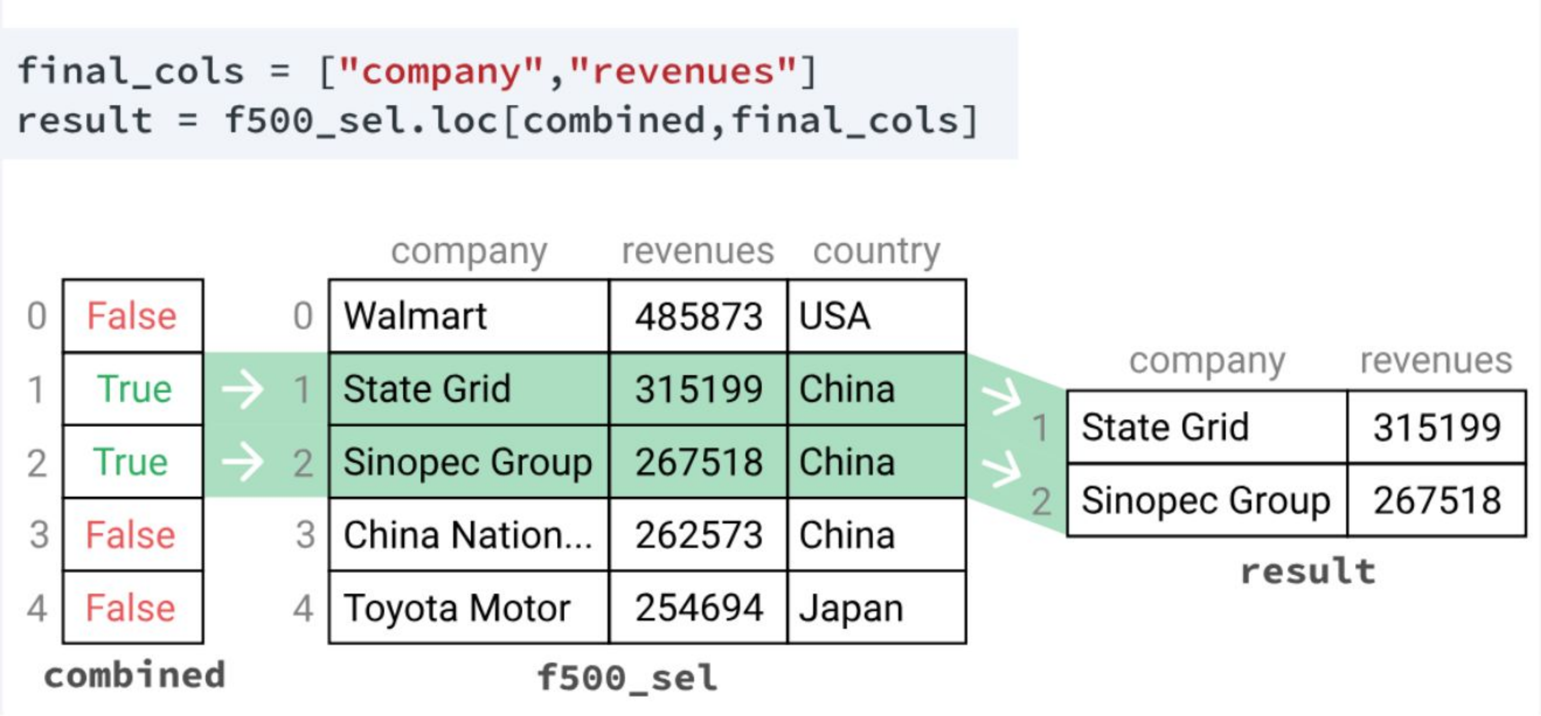
	over_265		china
0	True	0	False
1	True	1	True
2	True	2	True
3	False	3	True
4	False	4	False

```
combined = over_265 & china
```



	over_265			china			combined
0	True	&	0	False	=	0	False
1	True	&	1	True	=	1	True
2	True	&	2	True	=	2	True
3	False	&	3	True	=	3	False
4	False	&	4	False	=	4	False

Using boolean operators to select items



```
final_cols = ["company","revenues"]
result = f500_sel.loc[combined,final_cols]
```

combined

0	False
1	True
2	True
3	False
4	False

f500_sel

	company	revenues	country
0	Walmart	485873	USA
1	State Grid	315199	China
2	Sinopec Group	267518	China
3	China Nation...	262573	China
4	Toyota Motor	254694	Japan

result

	company	revenues
1	State Grid	315199
2	Sinopec Group	267518

Pandas Index Alignment

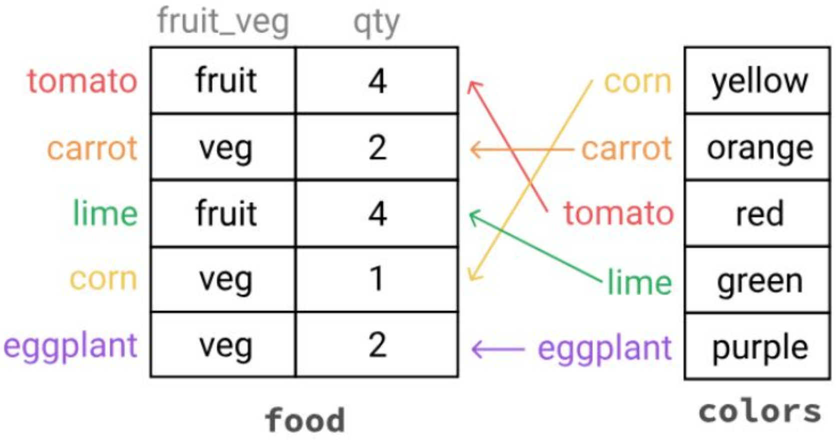
	fruit_veg	qty
tomato	fruit	4
carrot	veg	2
lime	fruit	4
corn	veg	1
eggplant	veg	2

food

corn	yellow
carrot	orange
tomato	red
lime	green
eggplant	purple

colors

```
food["color"] = colors
```



	fruit_veg	qty
tomato	fruit	4
carrot	veg	2
lime	fruit	4
corn	veg	1
eggplant	veg	2

food

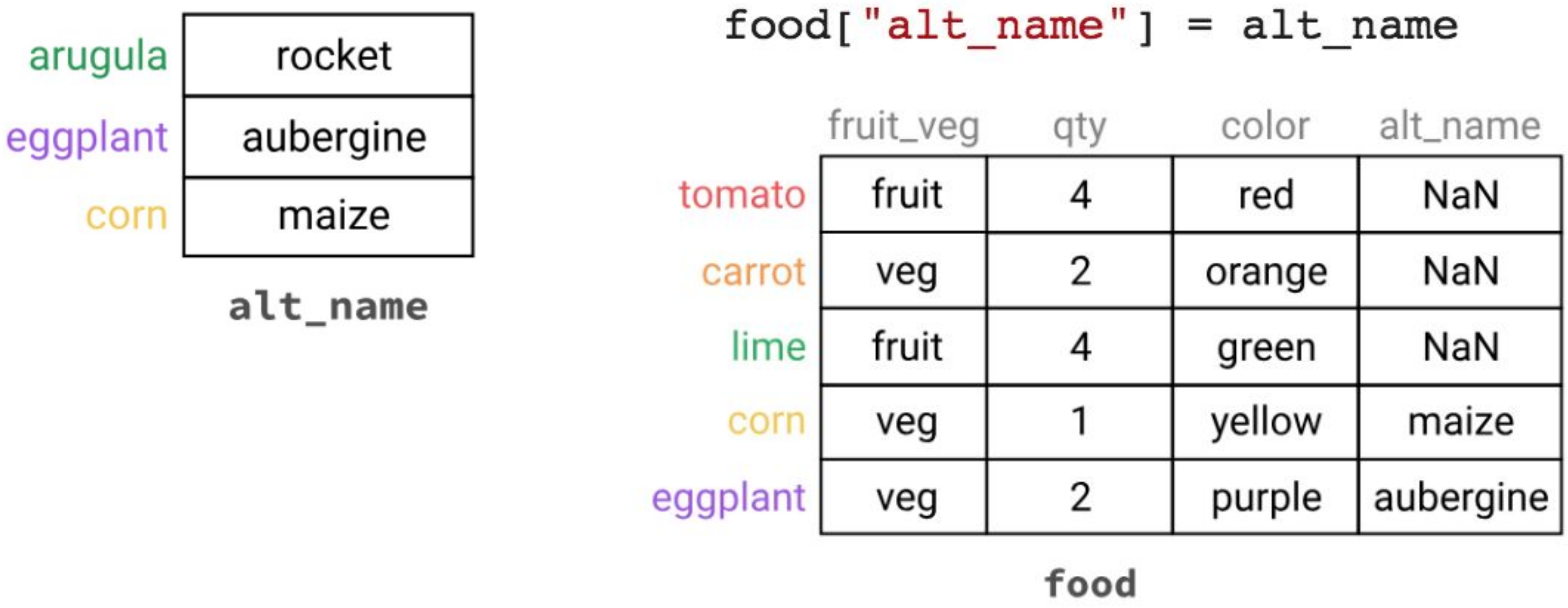
corn	yellow
carrot	orange
tomato	red
lime	green
eggplant	purple

colors

	fruit_veg	qty	color
tomato	fruit	4	red
carrot	veg	2	orange
lime	fruit	4	green
corn	veg	1	yellow
eggplant	veg	2	purple

food

Pandas Index Alignment



arugula	rocket
eggplant	aubergine
corn	maize

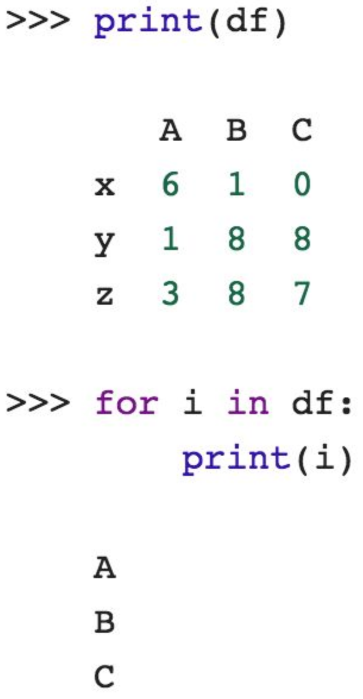
alt_name

```
food["alt_name"] = alt_name
```

	fruit_veg	qty	color	alt_name
tomato	fruit	4	red	NaN
carrot	veg	2	orange	NaN
lime	fruit	4	green	NaN
corn	veg	1	yellow	maize
eggplant	veg	2	purple	aubergine

food

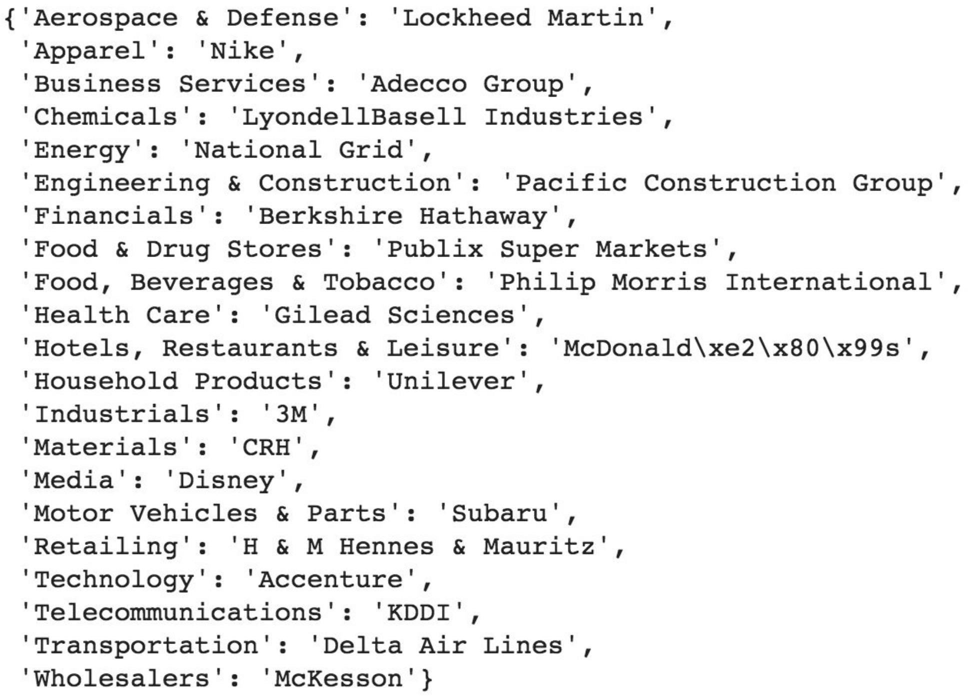
Using Loops in Pandas



```
>>> print(df)

    A  B  C
x   6  1  0
y   1  8  8
z   3  8  7

>>> for i in df:
        print(i)

    A
    B
    C
```

Because one of the key benefits of pandas is that it has vectorized methods to work with data more efficiently, we want to avoid using loops wherever we can

Challenge: calculating return on assets by sector



```
{'Aerospace & Defense': 'Lockheed Martin',
 'Apparel': 'Nike',
 'Business Services': 'Adecco Group',
 'Chemicals': 'LyondellBasell Industries',
 'Energy': 'National Grid',
 'Engineering & Construction': 'Pacific Construction Group',
 'Financials': 'Berkshire Hathaway',
 'Food & Drug Stores': 'Publix Super Markets',
 'Food, Beverages & Tobacco': 'Philip Morris International',
 'Health Care': 'Gilead Sciences',
 'Hotels, Restaurants & Leisure': 'McDonald\xe2\x80\x99s',
 'Household Products': 'Unilever',
 'Industrials': '3M',
 'Materials': 'CRH',
 'Media': 'Disney',
 'Motor Vehicles & Parts': 'Subaru',
 'Retailing': 'H & M Hennes & Mauritz',
 'Technology': 'Accenture',
 'Telecommunications': 'KDDI',
 'Transportation': 'Delta Air Lines',
 'Wholesalers': 'McKesson'}
```

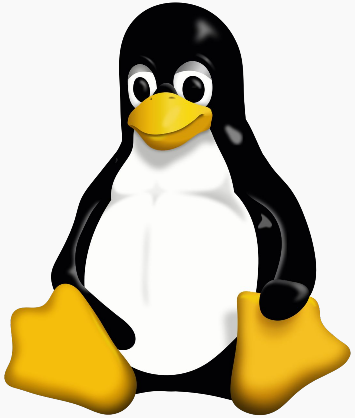
$$\text{return on assets} = \frac{profits}{assets}$$

Lesson_04 Part #2
Section 2.10

Challenge (...)

https://github.com/torvalds/linux

```
git log --encoding=latin-1 --pretty="%at,%aN" > log.csv
```



How many people contributed to the project?
Top #10 contributors?