How to …

```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
```

✓ Python

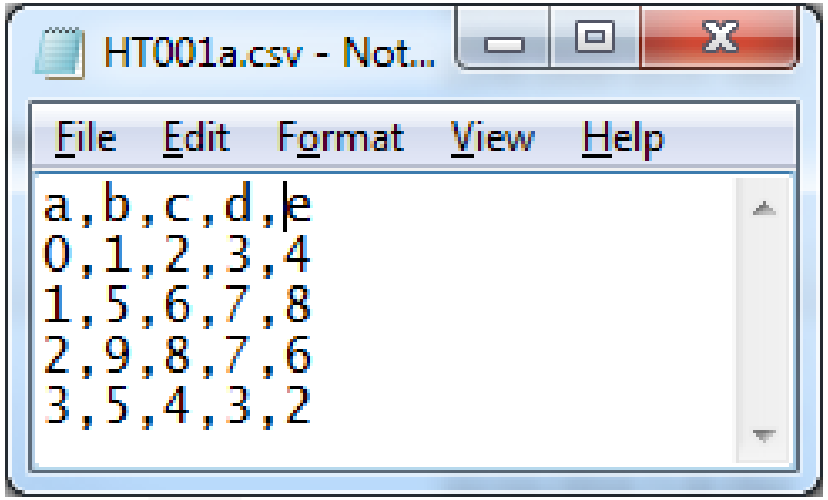
✓ MATLAB

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT001: **Use one command** to import data from a CSV file, **`HT001a.csv`**, using the **first row as column labels**, and the **first column as row labels**. Name the data imported as **`data`**.



✓ Python: **`pandas.read_csv`**

```
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
```

? MATLAB: **`readtable`**

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
```

099

SMU SINGAPORE MANAGEMENT UNIVERSITY

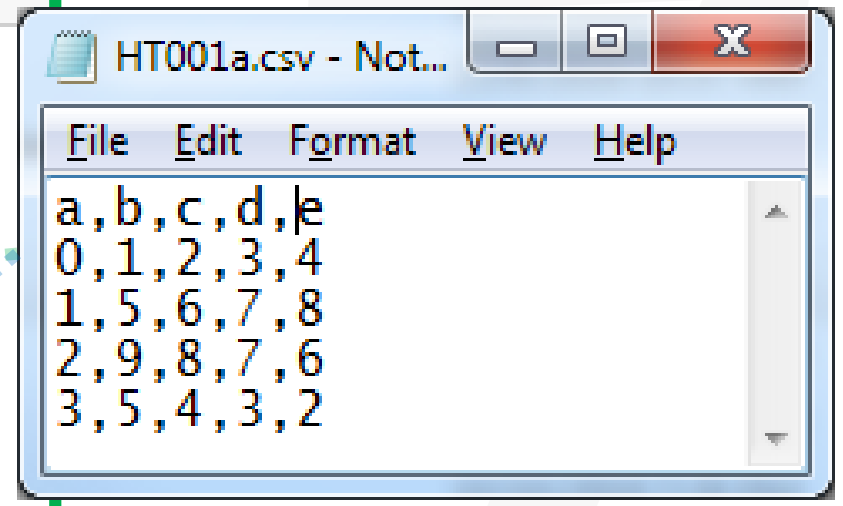
QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
data
```

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

Pandas DataFrame




```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
```

MATLAB Table

099

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

https://www.mathworks.com/help/matlab/ref/readtable.html

readtable

R2018a

Create table from file

collapse all in page

Syntax

```
T = readtable(filename)
T = readtable(filename,Name,Value)
T = readtable(filename,opts)
T = readtable(filename,opts,Name,Value)
```

Description

example

`T = readtable(filename)` creates a table by reading column oriented data from a file.

`readtable` determines the file format from the file extension:

- `.txt`, `.dat`, or `.csv` for delimited text files
- `.xls`, `.xlsb`, `.xlsm`, `.xltm`, `.xltx`, or `.ods` for spreadsheet files

`readtable` creates one variable in `T` for each column in the file and reads variable names from the first row of the file. By default, the variables created are `double` when the entire column is numeric, or cell arrays of character vectors when any element in a column is not numeric.

.csv

a table T

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

What if the file is newfolder\newfile.csv?

- ✓ `data=pd.read_csv('newfolder\\newfile.csv')`
- ✓ `data=pd.read_csv(r'newfolder\newfile.csv')`

(Mac) `data=pd.read_csv('newfolder/newfile.csv')`

100

- ✓ `data=readtable('newfolder\newfile.csv')`

(Mac) `data=readtable('newfolder/newfile.csv')`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Name-Value Pair Arguments

- **'ReadVariableNames' – Read first row as variable names**
- **'ReadRowNames' – Read first column as row names**
- 'DatetimeType' – Type for imported date and time date
- 'Delimiter' – Field delimiter character
- 'HeaderLines' – Lines to skip
- 'Format' – Column format
- 'EmptyValue' – Returned value for empty numeric fields
- 'DurationType' – Output data type of duration data

Spreadsheet Files Only

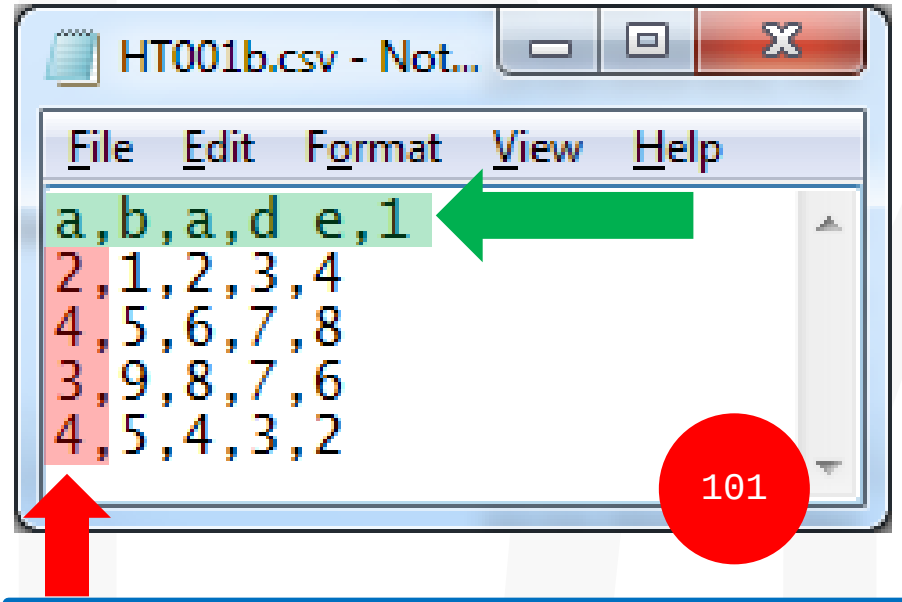
- 'Sheet' – Worksheet to read
- 'Range' – Portion of worksheet to read

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

What if the labels are as follows?



	b	a.1	d e	1
a				
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

`mangle_dupe_cols=True`

mangle_dupe_cols : *boolean, default True*
Duplicate columns will be specified as 'X', 'X.1', ...'X.N', rather than 'X'...'X'. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

Remember DataFrame is a dict-like container of Series??

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
                b     a     dE    x1
                _     _     __    __
    2           1     2     3     4
    4           5     6     7     8
    3           9     8     7     6
    4_1         5     4     3     2
```

```
d e -> dE
1 -> x1  (column label)
4 -> 4_1 (row label)
```

102

no duplicate names

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

	b	a.1	d e	1
a				
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

```
data.columns
```

```
Index(['b', 'a.1', 'd e', '1'], dtype='object')
```

```
data.index
```

```
Int64Index([2, 4, 3, 4], dtype='int64', name='a')
```

(continued)

101

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
```

	b	a	dE	x1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4_1	5	4	3	2

102

column labels

```
data.Properties.VariableNames
```

```
ans =
    'b'    'a'    'dE'    'x1'
```

1x4

row labels

```
data.Properties.RowNames
```

```
ans =
    '2'
    '4'
    '3'
    '4_1'
```

4x1

cell array

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT002: Use an appropriate **position-based indexing/slicing** method to select data in **`data`**.

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

✓ `data.iloc[0,0]`

× `data[0][0]`

× `data[0,0]`

103

DataFrame ⇨ Number

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
                b     a     dE     x1
              ____  ____  ____  ____
    2            1     2     3     4
    4            5     6     7     8
    3            9     8     7     6
    4_1          5     4     3     2
```

✓ `data{1, 1}`

✓ `data(1, 1)`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

position-based indexing

```
data{1,1}
```

```
ans =
     1
```

1x1 **double**

103

```
data(1,1)
```

```
ans =
        b
        _
    2   1
```

1x1 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

(continued)

position-based slicing (1)

a	b	a.1	d	e	1
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	
4	5	4	3	2	

`data.iloc[0:2,0:2]`

DataFrame⇨DataFrame

a	b	a.1
2	1	2
4	5	6

103

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
                b     a     dE     x1
                _     _     __     __
    2           1     2     3      4
    4           5     6     7      8
    3           9     8     7      6
    4_1         5     4     3      2
```

✓ `data{1:2, 1:2}`
✓ `data(1:2, 1:2)`

https://www.mathworks.com/help/matlab/matlab_prog/access-data-in-a-table.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

position-based slicing (1)

```
data{1:2, 1:2}
```

```
ans =
     1     2
     5     6
```

2x2 **double**

103

```
data(1:2, 1:2)
```

```
ans =
              b     a
              _     _
     2        1     2
     4        5     6
```

2x2 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

(continued)

position-based slicing (2)

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

(the 1st row)

```
data.iloc[0,:]
```

DataFrame⇨Series

```
b      1
a.1    2
d e    3
1      4
Name: 2, dtype: int64
```

103

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
              b     a     dE     x1
              _     _     __     __
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

✓ data{1, :}

✓ data(1, :)

https://www.mathworks.com/help/matlab/matlab_prog/access-data-in-a-table.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

position-based slicing (2): the 1st row

```
data(1, :)
```

```
ans =
     1     2     3     4
```

1x4 **double**

103

```
data(1, :)
```

```
ans =
                b     a     dE    x1
                _     _     __    __
    2           1     2     3     4
```

1x4 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

(continued)

position-based slicing (3)

a	b	a.1	d	e	1
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	
4	5	4	3	2	

(the 1st column)

```
data.iloc[:,0]
```

DataFrame⇨Series

```
a
2    1
4    5
3    9
4    5
Name: b, dtype: int64
```

103

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
              b     a     dE     x1
              _     _     __     __
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

✓ `data{:, 1}`
✓ `data(:, 1)`

https://www.mathworks.com/help/matlab/matlab_prog/access-data-in-a-table.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

position-based slicing (3): the 1st column

```
data{:, 1}
```

```
ans =
     1
     5
     9
     5
```

4x1 **double**

103

```
data(:, 1)
```

```
ans =
            b
            _
    2       1
    4       5
    3       9
    4_1     5
```

4x1 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Assume the table consists of numbers only.

104

`data.values` ⇔ **`data{:, :}`**

⇨ Numpy 2D ndarray

⇨ 2D array

`data.Variables`

R2018a

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
data{:,:}
```

```
data{:,:}
```

```
ans =
     1     2     3     4
     5     6     7     8
     9     8     7     6
     5     4     3     2
```

4x4 **double**

104

```
data(:,:)
```

```
data(:,:)
```

```
ans =
              b     a     dE    x1
              _     _     __    __
     2        1     2     3     4
     4        5     6     7     8
     3        9     8     7     6
     4_1      5     4     3     2
```

4x4 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

(continued)

	b	a.1	d	e	1
a					
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	
4	5	4	3	2	

position-based fancy indexing

103

```
data.iloc[[2,0],[0,1]]
```

DataFrame⇨DataFrame

(Dr. Z: Fancy indexing is similar to slicing.)

	b	a.1
a		
3	9	8
2	1	2

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
              b     a     dE     x1
              _     _     __     __
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

✓ `data{[3 1], [1 2]}`
✓ `data([3 1], [1 2])`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

fancy indexing

```
data{[3 1],[1 2]}
```

```
ans =
     9     8
     1     2
```

2x2 **double**

103

```
data([3 1],[1 2])
```

```
ans =
           b     a
           _     _
     3     9     8
     2     1     2
```

2x2 **table**

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT003: Use an appropriate **label-based indexing/slicing** method to select data in **data**.

a	b	a.1	d	e	1
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	
4	5	4	3	2	

✓ `data.loc[2,'b']`
✓ `data['b'][2]`
× `data[2,'b']`

105

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
                b     a     dE     x1
              ___   ___   ___    ___
    2           1     2     3      4
    4           5     6     7      8
    3           9     8     7      6
    4_1         5     4     3      2
```

✓ `data{'2', 'b'}`
✓ `data('2', 'b')`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

label-based indexing

```
data{'2','b'}
```

```
ans =
     1
```

1x1 **double**

105

```
data('2','b')
```

```
ans =
          b
    2     1
```

1x1 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

(continued)

label-based slicing (1)

a	b	a.1	d	e	1
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	
4	5	4	3	2	

```
data.loc[2:3,'b':'1']
```

105

a	b	a.1	d	e	1
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
```

	b	a	dE	x1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4_1	5	4	3	2

https://www.mathworks.com/help/matlab/matlab_prog/access-data-in-a-table.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

(continued)

label-based slicing (2)

(row with label 2)

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

```
data.loc[2,:]
```

105

```
b       1
a.1     2
d e     3
1       4
Name: 2, dtype: int64
```

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
```

	b	a	dE	x1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4_1	5	4	3	2

✓ `data{'2', :}`
✓ `data('2', :)`

https://www.mathworks.com/help/matlab/matlab_prog/access-data-in-a-table.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

label-based slicing (2): row with label 2

```
data{'2',:}
```

```
ans =
     1     2     3     4
```

1x4 **double**

105

```
data('2',:)
```

```
ans =
          b     a     dE    x1
          _     _     __    __
    2     1     2     3     4
```

1x4 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

(continued)

label-based slicing (3)

(column with label a.1)

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

```
data.loc[:, 'a.1']
```

105

```
a
2    2
4    6
3    8
4    4
Name: a.1, dtype: int64
```

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
```

	b	a	dE	x1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4_1	5	4	3	2

✓ data{:, 'a'}
✓ data(:, 'a')

https://www.mathworks.com/help/matlab/matlab_prog/access-data-in-a-table.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

label-based slicing (3): column with label a

```
data{:, 'a'}
```

```
ans =
     2
     6
     8
     4
```

4x1 **double**

105

```
data(:, 'a')
```

```
ans =
              a
              _
     2        2
     4        6
     3        8
     4_1      4
```

4x1 **table**

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

(continued)

label-based fancy indexing

a	b	a.1	d	e	1
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	
4	5	4	3	2	

```
data.loc[[2,3],['b','1']]
```

105

a	b	1
2	1	4
3	9	6

```
Warning: Variable names were modified to make them valid MATLAB identifiers.
data =
              b     a     dE     x1
              _     _     __     __
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

- ✓ `data{{'2','3'},{'b','x1'}}`
- ✓ `data({'2','3'},{'b','x1'})`

https://www.mathworks.com/help/matlab/matlab_prog/access-data-in-a-table.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

label-based fancy indexing

```
data{{'2','3'},{'b','x1'}}
```

```
ans =
     1     4
     9     6
```

2x2 **double**

105

```
data({'2','3'},{'b','x1'})
```

```
ans =
  2×2 table
    b    x1
    _    __
    1    4
    9    6
```

2x2 **table**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

HT004: Use one command to add a column to **data** with a specific name.

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

106

- ✓ `data['f1']=1`
- ✓ `data.loc[:,'f1']=1`

1. a number
2. an iterable
3. A Numpy array
4. a Series
5. a DataFrame

a	b	a.1	d e	1	f1
2	1	2	3	4	1
4	5	6	7	8	1
3	9	8	7	6	1
4	5	4	3	2	1

107

- ✓ `data['f2']=range(4)`
- ✓ `data.loc[:,'f2']=range(4)`
- ✓ `…=[0,1,2,3]`
- ✓ `…=[[0],[1],[2],[3]]`
- × `…=[[0,1,2,3]]`

a	b	a.1	d e	1	f1	f2
2	1	2	3	4	1	0
4	5	6	7	8	1	1
3	9	8	7	6	1	2
4	5	4	3	2	1	3

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# add a column (3): a Numpy array
import numpy as np
np.arange(4)
```

```
array([0, 1, 2, 3])
```

```
np.arange(4).reshape(4,1)
```

```
array([[0],
       [1],
       [2],
       [3]])
```

```
np.arange(4).reshape(1,4)
```

```
array([[0, 1, 2, 3]])
```

✓ `data['f3']=np.arange(4)`

✓ `data['f3']=np.arange(4).reshape(4,1)`

× `data['f3']=np.arange(4).reshape(1,4)`

a	b	a.1	d	e	1	f1	f2	f3
2	1	2	3	4	1	0	0
4	5	6	7	8	1	1	1
3	9	8	7	6	1	2	2
4	5	4	3	2	1	3	3

1D array or 2D column array

1. a number
2. an iterable
3. A Numpy array
4. a Series
5. a DataFrame

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

```
# add a column (4): a Series (with different labels)
pd.Series(range(4))
```

```
0    0
1    1
2    2
3    3
dtype: int64
```

```
data['f4']=pd.Series(range(4))
data
```

	b	a.1	d	e	1	f1	f2	f3	f4
a									
2	1	2	3	4	1	0	0		2.0
4	5	6	7	8	1	1	1		NaN
3	9	8	7	6	1	2	2		3.0
4	5	4	3	2	1	3	3		NaN

1. a number
2. an iterable
3. A Numpy array
4. a Series
5. a DataFrame

109

? `data['f4']=pd.Series(range(3))`
? `data['f4']=pd.Series(range(4))`
? `data['f4']=pd.Series(range(5))`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
? data['f5']=pd.DataFrame([[i] for i in range(3)])
? data['f5']=pd.DataFrame([[i] for i in range(4)])
? data['f5']=pd.DataFrame([[i] for i in range(5)])
```

```
# add a column (5): a DataFrame
pd.DataFrame([[i] for i in range(4)])
```

	0
0	0
1	1
2	2
3	3

110

1. a number
2. an iterable
3. a Numpy array
4. a Series
5. a DataFrame

```
pd.DataFrame([[i for i in range(4)]], index=[2])
```

	0	1	2	3
2	0	1	2	3

```
data['f5']=pd.DataFrame([[i] for i in range(4)])
data
```

	b	a.1	d	e	1	f1	f2	f3	f4	f5
a										
2	1	2	3	4	1	0	0		2.0	2.0
4	5	6	7	8	1	1	1		NaN	NaN
3	9	8	7	6	1	2	2		3.0	3.0
4	5	4	3	2	1	3	3		NaN	NaN

So, how to assign a row's value to a column in a DataFrame??

```
× data['f5']=pd.DataFrame([[i for i in range(4)]],index=[2])
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

Homework: Use one command to add a column to **data**, using the first row of **data**, and name this column **f**.

```
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
data
```

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

111

???

a	b	c	d	e	f
0	1	2	3	4	1
1	5	6	7	8	2
2	9	8	7	6	3
3	5	4	3	2	4

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

DataFrame

1. .values
2. .as_matrix()
3. numpy.asarray
- _____?

ndarray (2D)

8. Selection by []
9. Selection by .loc
10. Selection by .iloc
- _____?

Hint

112

4. Indexing
5. .flatten()
6. .ravel()
7. .reshape()
- _____?

Series

11. .ravel()
12. numpy.asarray
13. .as_matrix()
14. .values
- _____?

ndarray (1D)

HT004: Use one command to add a column to **data** with a specific name.

	b	a	dE	x1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4_1	5	4	3	2

113

- × `data.f1=1`
- ⇨ `data.f1(:)=1`
- ✓ `data.f1(:,1)=1`
- ✓ `data{:,'f1'}=1`
- × `data(:,'f1')=1`
- ✓ `data(:,'f1')={1}`

`data =`

	b	a	dE	x1	f1
2	1	2	3	4	1
4	5	6	7	8	1
3	9	8	7	6	1
4_1	5	4	3	2	1

1. a number
2. an array

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

1. a number
2. an array

× `data.f1=[1,2,3,4]`
✓ `data.f1=[1;2;3;4]`
? `data.f1={1;2;3;4}`
× `data.f1(:)=[1;2;3;4]`
× `data.f1(:)={1;2;3;4}`
× `data.f1(:)=1:4`
✓ `data.f1(:,1)=[1;2;3;4]`
✓ `data.f1(:,1)=1:4`
✓ `data{:,'f1'}=[1;2;3;4]`
? `data{:,'f1'}=1:4`

	b	a	dE	x1	f1
2	1	2	3	4	1
4	5	6	7	8	2
3	9	8	7	6	3
4_1	5	4	3	2	4

To **assign to** or **create** a **variable** in a table, **the number of rows must match the height of the table**.

In an assignment A(:) = B, the number of elements in A and B must be the same.

114

`[1;2;3;4]⇔(1:4)'`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Homework: Use one command to add a column to **data**, using the first row of **data**, and name this column **f**.

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
```

```
??????????????????????????
```

```
data =

          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =

          b    c    d    e    f
          _    _    _    _    _
    0     1    2    3    4    1
    1     5    6    7    8    2
    2     9    8    7    6    3
    3     5    4    3    2    4
```

115

SMU SINGAPORE MANAGEMENT UNIVERSITY

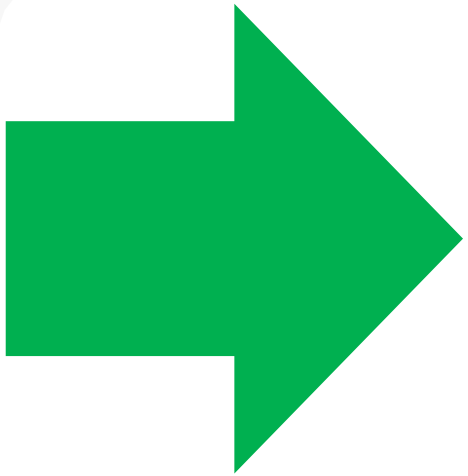
QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT005: Use one command to add a row to **data** with a specific name.

- ✓ **data.loc[rowname,:]=…**
- ✓ **data=data.append(…)**

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2



a	b	c	d	e
0	1.0	2.0	3.0	4.0
1	5.0	6.0	7.0	8.0
2	9.0	8.0	7.0	6.0
3	5.0	4.0	3.0	2.0
100	1.0	1.0	1.0	1.0

116

a	b	c	d	e
0	1.0	2.0	3.0	4.0
1	5.0	6.0	7.0	8.0
2	9.0	8.0	7.0	6.0
3	5.0	4.0	3.0	2.0
100	1.0	2.0	3.0	4.0

117

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

- ✓ `data.loc[rowname,:]=…`
- ✓ `data.append(…)`

HT005: Use one command to add a row to **data** with a specific name.

116

- ✓ `data.loc[100,:]=1`
- ✓ `data.loc[100,:]=[1]`
- × `data.loc[100,:]=[[1]]`
- ✓ `data.loc[100,:]=np.array(1)`
- ✓ `data.loc[100,:]=np.array([1])`
- ✓ `data.loc[100,:]=np.array([[1]])`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

✓ `data.loc[rowname,:]=…`
✓ `data.append(…)`

HT005: Use one command to add a row to **data** with a specific name.

✓ `data.loc[100,:]=range(1,5)`
✓ `data.loc[100,:]=[1, 2, 3, 4]`
× `data.loc[100,:]=[[1, 2, 3, 4]]`
× `data.loc[100,:]=[[1],[2],[3],[4]]`
✓ `data.loc[100,:]=np.array([1,2,3,4])`
✓ `data.loc[100,:]=np.array([[1,2,3,4]])`
× `data.loc[100,:]=np.array([[1],[2],[3],[4]])`

117

Dr. Z: 1D for 1D (100%).

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

https://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.append.html

pandas.DataFrame.append

`DataFrame.append(other, ignore_index=False, verify_integrity=False, sort=None)` [source]

Append rows of *other* to the end of this frame, returning a new object. Columns not in this frame are added as new columns.

```
data=data.append(…)
```

Parameters:

other : *DataFrame or Series/dict-like object, or list of these*
The data to append.

ignore_index : *boolean, default False*
If True, do not use the index labels.

verify_integrity : *boolean, default False*
If True, raise ValueError on creating index with duplicates.

sort : *boolean, default None*
Sort columns if the columns of *self* and *other* are not aligned. The default sorting is deprecated and will change to not-sorting in a future version of pandas. Explicitly pass `sort=True` to silence the warning and sort. Explicitly pass `sort=False` to silence the warning and not sort.
New in version 0.23.0.

Returns:

appended : *DataFrame*

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

```
# a dictionary
%reset -f
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
#data=data.append({k:1 for (v,k) in enumerate(data.columns,1)},ignore_index=True)
data=data.append({k:v for (v,k) in enumerate(data.columns,1)},ignore_index=True)
data
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
4	1	2	3	4

118

The dictionary does not have index to use. **`ignore_index=False`** will cause an error.

a dictionary

Key ⇔ column names

Cannot specify row name.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# Error: a dictionary + "ignore_index=False"
%reset -f
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
#data=data.append({k:1 for (v,k) in enumerate(data.columns,1)})
data=data.append({k:v for (v,k) in enumerate(data.columns,1)})
data
```

ignore_index=False

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-97-cfeaf4369542> in <module>()
      4 data=pd.read_csv('HT001a.csv', index_col=0, header=0)
      5 #data=data.append({k:1 for (v,k) in enumerate(data.columns,1)})
----> 6 data=data.append({k:v for (v,k) in enumerate(data.columns,1)})
      7 data

C:\Continuum\anaconda3\lib\site-packages\pandas\core\frame.py in append(self, other, ignore_index, ver
ify_integrity, sort)
   6175                 other = Series(other)
   6176             if other.name is None and not ignore_index:
-> 6177                 raise TypeError('Can only append a Series if ignore_index=True'
   6178                                 ' or if the Series has a name')
   6179

TypeError: Can only append a Series if ignore_index=True or if the Series has a name
```

(Dr. Z: The dictionary does not suggest any name.)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# a list of dictionaries
%reset -f
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
#data=data.append([{k:1 for (v,k) in enumerate(data.columns,1)}])
data=data.append([{k:v for (v,k) in enumerate(data.columns,1)}])
data
```

ignore_index=False

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

a list of dictionaries

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
0	1	2	3	4

118

Key ⇔ column names

If using **ignore_index=True**, the row label will be 4.

118

Cannot specify row name.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# a Series
%reset -f
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
#data=data.append(pd.Series(1, index=data.columns),
#data=data.append(pd.Series([1,2,3,4], index=data.columns),
data=data.append(pd.Series(range(1,5), index=data.columns),
                                        ignore_index=True)
data
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
4	1	2	3	4

The Series does not have an index to be used as row index. **`ignore_index=False`** will cause an error.

118

a Series

Series Index ⇔ column names

Cannot specify row name.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# a list of Serieses
%reset -f
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
#data=data.append([pd.Series(1, index=data.columns)])
#data=data.append([pd.Series([1,2,3,4], index=data.columns)])
data=data.append([pd.Series(range(1,5), index=data.columns)])
data
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
0	1	2	3	4

ignore_index=False

a list of Series

Series Index ⇔ column names

If using **ignore_index=True**, the row label will be 4.

Cannot specify row name.

118

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# a DataFrame
%reset -f
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
#data=data.append(pd.DataFrame(1,
#data=data.append(pd.DataFrame([[i for i in range(1,5)]],
data=data.append(pd.DataFrame(np.arange(1,5).reshape(1,4),
                              columns=data.columns,
                              index=[100]))
data
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
100	1	2	3	4

ignore_index=False

index=[100]

Index or array-like

116

117

a DataFrame

HT005: Use one command to add a row to **data** with a specific name.

If using **ignore_index=True**, the row label will be 4.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT005: Use one command to add a row to **data** with a specific name.

✓ Add a column

```
× data.f1=1
⇨ data.f1(:)=1
✓ data.f1(:,1)=1
✓ data{:,'f1'}=1
× data(:,'f1')=1
✓ data(:,'f1')={1}
```

```
× data.f1=[1,2,3,4]
✓ data.f1=[1;2;3;4]
? data.f1={1;2;3;4}
× data.f1(:)=[1;2;3;4]
× data.f1(:)={1;2;3;4}
× data.f1(:)=1:4
✓ data.f1(:,1)=[1;2;3;4]
✓ data.f1(:,1)=1:4
✓ data{:,'f1'}=[1;2;3;4]
? data{:,'f1'}=1:4
```

✓ Add a row

```
× data.f1=1
× data.f1(:)=1
× data.f1(1,:)=1
✓ data{'4',:}=1
× data('4',:)=1
✓ data('4',:)={1}
```

119

```
× data.f1=[1,2,3,4]
× data.f1=[1;2;3;4]
× data.f1={1;2;3;4}
× data.f1(:)=[1;2;3;4]
× data.f1(:)={1;2;3;4}
× data.f1(:)=1:4
× data.f1(1,:)=[1;2;3;4]
× data.f1(1,:)=1:4
✓ data{'4',:}=[1,2,3,4]
✓ data{'4',:}=1:4
```

120

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT006: Delete a row/column from `data`

1. Delete a column as deleting an item in a dictionary

```
del data['b']
```

(in-place delete)

121

2. Use `pandas.DataFrame.drop`

```
axis=0, inplace=False
```

(default)

```
0 or 'index', 1 or 'columns'
```

pandas.DataFrame.drop

`DataFrame.drop(labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')`

[source]

Drop specified labels from rows or columns.

Remove rows or columns by specifying label names and corresponding axis, or by specifying directly index or column names. When using a multi-index, labels on different levels can be removed by specifying the level.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
%reset -f
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
del data['b']
print(data)
data.drop('c', axis=1, inplace=True)
print(data)
data.drop(data.columns[0], axis=1, inplace=True)
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   c  d  e
a
0  2  3  4
1  6  7  8
2  8  7  6
3  4  3  2
   d  e
a
0  3  4
1  7  8
2  7  6
3  3  2
   e
a
0  4
1  8
2  6
3  2
```

121 122

del data['b'] or **del data[data.columns[0]]**

```
data.drop('c',
          axis=1,
          inplace=True)
```

```
data.drop(data.columns[0],
          axis=1,
          inplace=True)
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT006: Delete a row/column from **data**

```
pandas.DataFrame.drop

data.index

axis=0

inplace=True
```

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
%reset -f
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.drop(0, inplace=True)
print(data)
data.drop(data.index[0], inplace=True)
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
2  9  8  7  6
3  5  4  3  2
```

123 124

data.drop(0, inplace=True)

data.drop(data.index[0], inplace=True)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT006: Delete a row/column from `data`

- ✓ Delete a column using the “dot syntax”

```
data.b=[]
```

- ✓ Delete a column using the indexing (position-based and label-based)

```
data(:,1)=[]
```

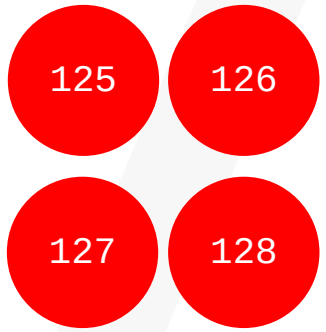
```
data(:,'b')=[]
```

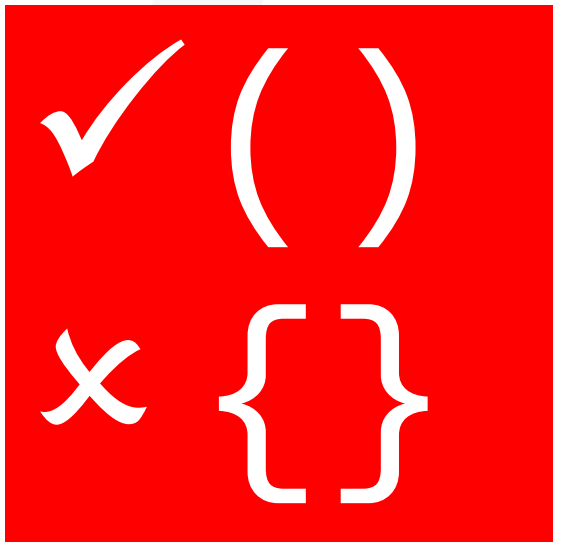
- ✓ Delete a row by the row number

```
data(1,:)=[]
```

- ✓ Delete a row by the row name

```
data('0',:)=[]
```





SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Delete a column using the dot syntax

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data.b=[]
```

```
data.b=[]
```

```
data =
    b    c    d    e
    _    _    _    _
0   1    2    3    4
1   5    6    7    8
2   9    8    7    6
3   5    4    3    2
data =
    c    d    e
    _    _    _
0   2    3    4
1   6    7    8
2   8    7    6
3   4    3    2
```

✓ Delete the column 'b'

Delete a column using label-based indexing

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data(:,'b')=[]
```

```
data(:,'b')=[]
```

```
data =
    b    c    d    e
    _    _    _    _
0   1    2    3    4
1   5    6    7    8
2   9    8    7    6
3   5    4    3    2
data =
    c    d    e
    _    _    _
0   2    3    4
1   6    7    8
2   8    7    6
3   4    3    2
```

125 126

Delete a column using position-based indexing

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data(:,1)=[]
```

```
data(:,1)=[]
```

```
data =
    b    c    d    e
    _    _    _    _
0   1    2    3    4
1   5    6    7    8
2   9    8    7    6
3   5    4    3    2
data =
    c    d    e
    _    _    _
0   2    3    4
1   6    7    8
2   8    7    6
3   4    3    2
```

✓ Delete the first column

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Delete a row by the row number

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data(1,:)=[]
```

data(1,:)=[]

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
```

✓ **Delete the first row**

127 128

Delete a row by the row name

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data('0',:)=[]
```

data('0',:)=[]

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
```

✓ **Delete the row '0'**

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

Q: How to swap two values in variables a and b?

```
??????????????????????????????
?                              ?
?   a=b                        ?
?   b=a                        ?
?                              ?
??????????????????????????????
```

```
>>> a=1
>>> b=2
>>> a=b
>>> b=a
>>> a,b
(2, 2)
```

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

(continued)

```
temp=a
a=b
b=temp
```

129

```
>>> a=1
>>> b=2
>>> temp=a
>>> a=b
>>> b=temp
>>> a,b
(2, 1)
```

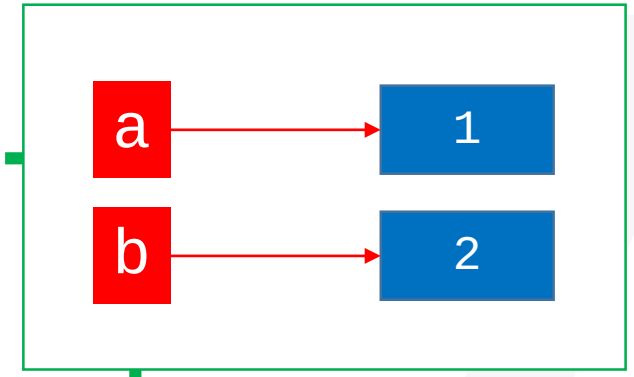
SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

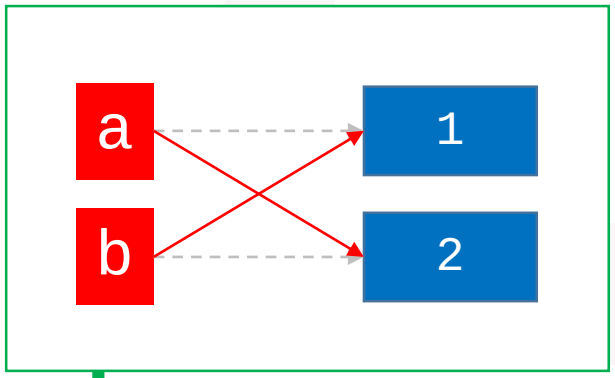
Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

(continued)

```
>>> a=1
>>> b=2
>>> a, b=b, a
>>> a,b
(2, 1)
```



expr3, expr4=expr1, expr2



129

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>> a=1;
>> b=2;
>> temp=a;
>> a=b;
>> b=temp;
>> a
a =
     2
>> b
b =
     1
```

```
a, b=b, a
1  2    3
```

130

```
>> a=1;
>> b=2;
>> [a,b]=deal(b,a)
a =
     2
b =
     1
```

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT007: Swap two rows/columns in `data`

```
# A wrong answer to swap two columns
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
temp=data['b']
data['b']=data['c']
data['c']=temp
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  2  3  4
1  6  6  7  8
2  8  8  7  6
3  4  4  3  2
```

????

1. Select data via [ ]
2. Select data via `.loc` or `.iloc`

`temp` does not work!

`data['b']` and **`data['c']`** are views. A view is something like a "pointer". Assignment to a view is function to use the pointer to assign values.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# Another wrong answer to swap to columns
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data['b'], data['c']=data['c'], data['b']
print(data)
```

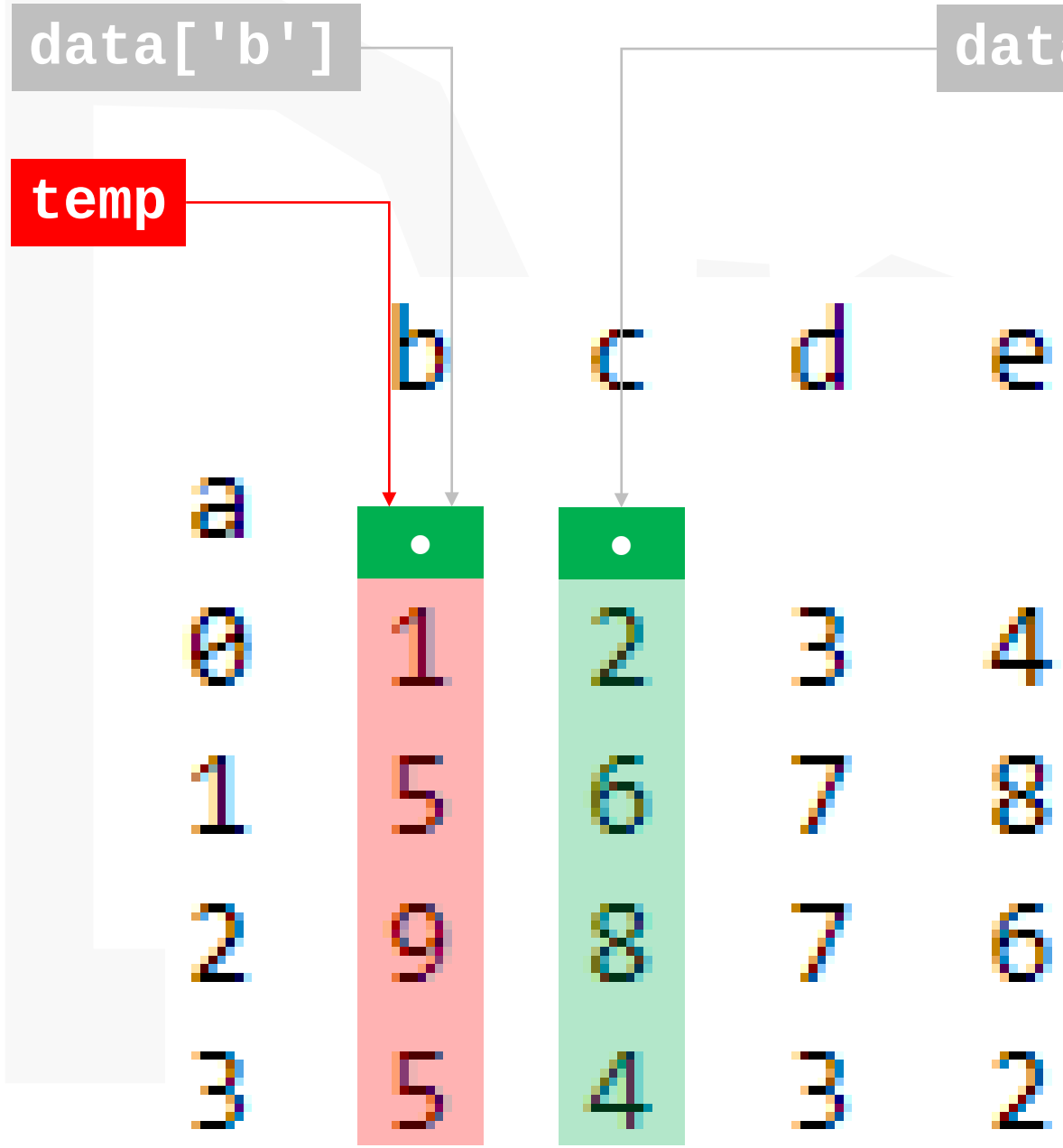
```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  2  3  4
1  6  6  7  8
2  8  8  7  6
3  4  4  3  2
```

????

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance




```
temp=data['b']
data['b']=data['c']
data['c']=temp
```

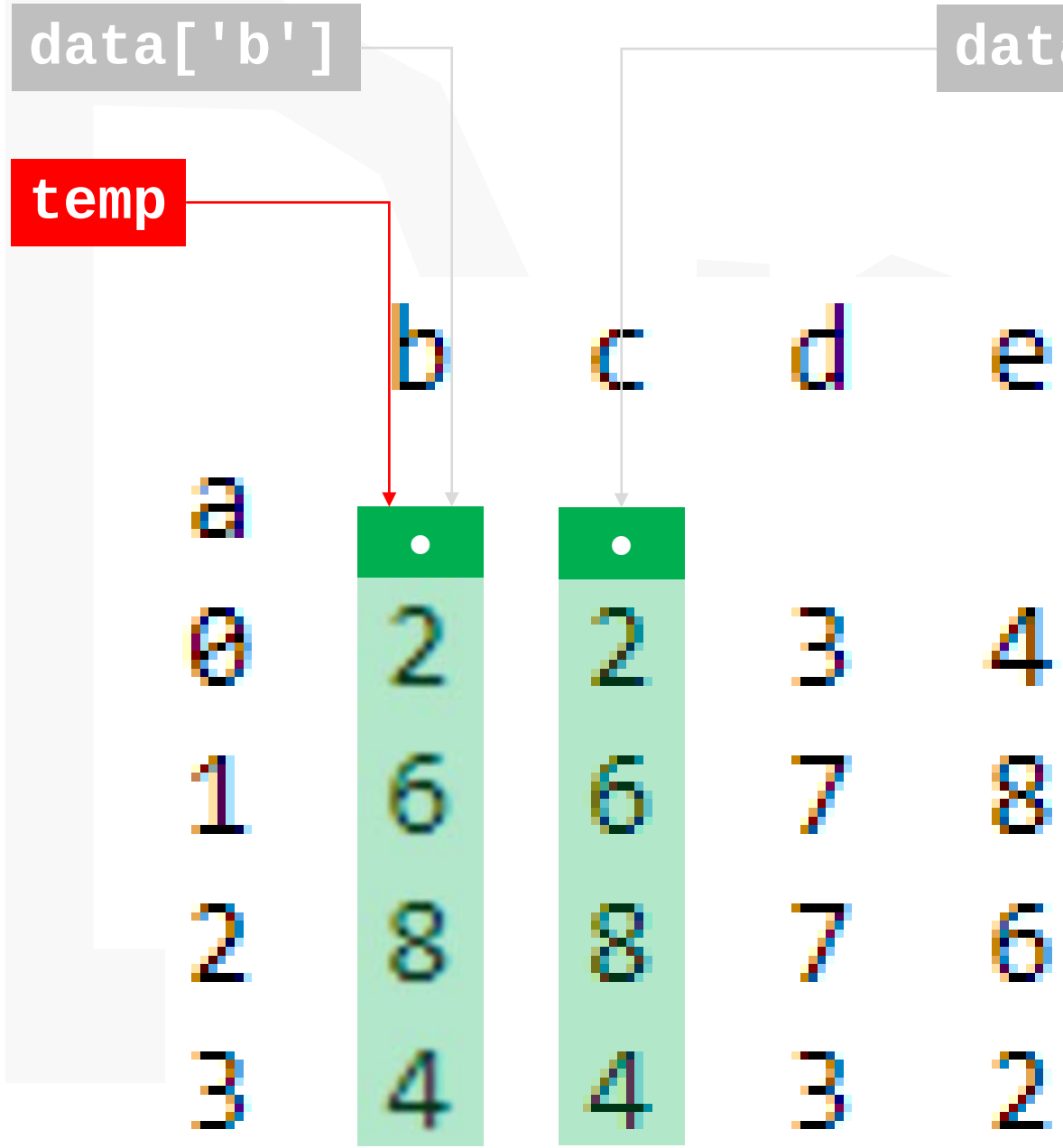
```
temp=data['b']
temp[0]=100
data
```

a	b	c	d	e
0	100	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance




```
temp=data['b']
data['b']=data['c']
data['c']=temp
```

```
temp=data['b']
data['b']=data['c']
data
```

a	b	c	d	e
0	2	2	3	4
1	6	6	7	8
2	8	8	7	6
3	4	4	3	2

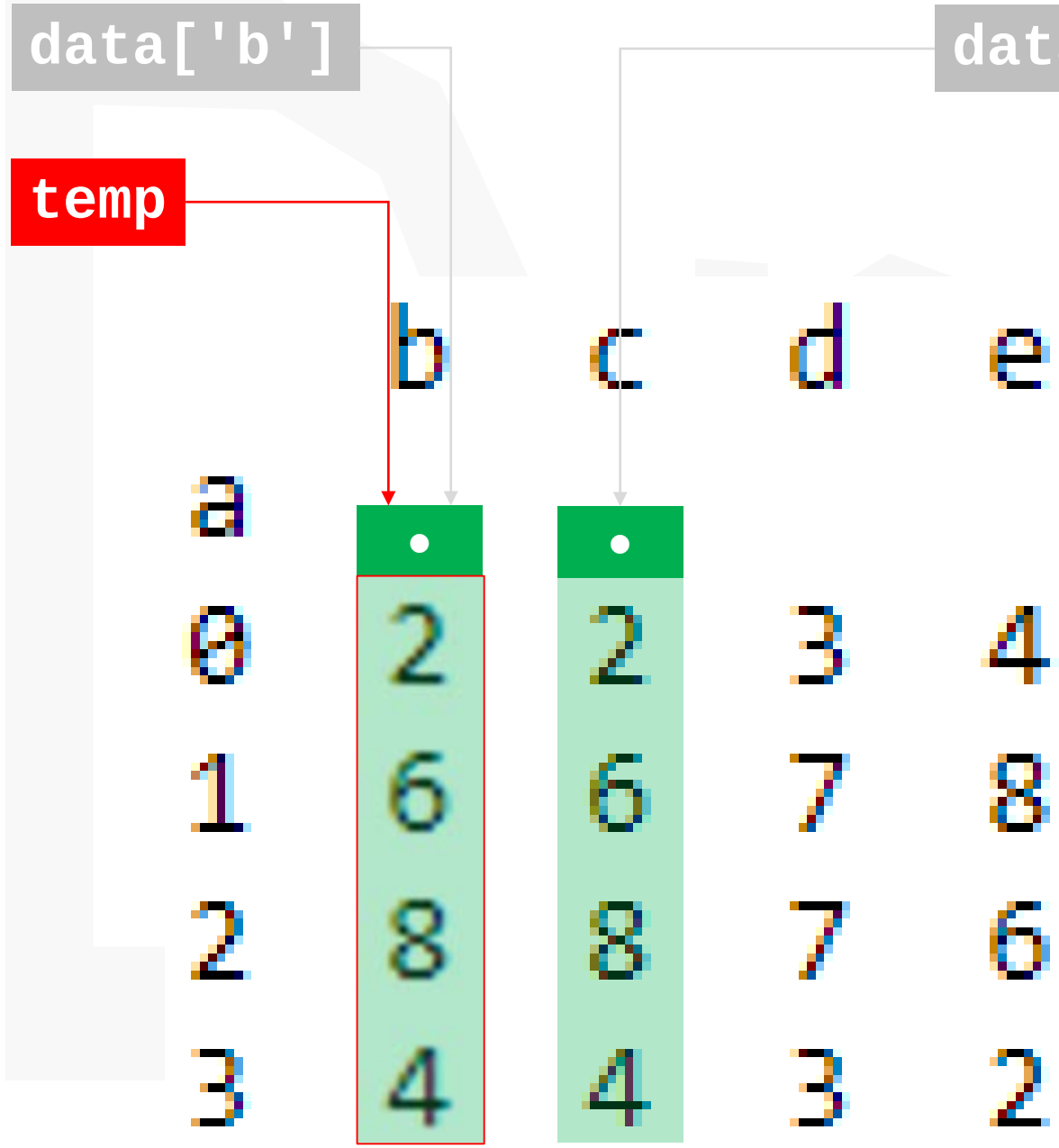
```
temp
```

```
a
0    2
1    6
2    8
3    4
Name: b, dtype: int64
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance




```
temp=data['b']
data['b']=data['c']
data['c']=temp
```

Dr. Z's interpretation on the assignment to a view

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
data=[[1,2],[3,4]]
print(data)
data[0]=data[1]
print(data)
data[0][0]=100
print(data)
```

```
[[1, 2], [3, 4]]
[[3, 4], [3, 4]]
[[100, 4], [100, 4]]
```

```
import numpy as np
x=[[1,2],[3,4]]
data=np.array(x)
print(data)
data[0]=data[1]
print(data)
data[0][0]=100
print(data)
```

```
[[1 2]
 [3 4]]
[[3 4]
 [3 4]]
[[100   4]
 [  3   4]]
```

copy

```
import pandas as pd
x=[[1,2],[3,4]]
data=pd.DataFrame(x)
print(data)
data.iloc[0]=data.iloc[1]
print(data)
data.iloc[0][0]=100
print(data)
```

```
   0  1
0  1  2
1  3  4
   0  1
0  3  4
1  3  4
     0  1
0  100  4
1    3  4
```

copy

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```python
# swap two columns (1)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
temp=data['b'].copy()
data['b']=data['c']
data['c']=temp
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  1  3  4
1  6  5  7  8
2  8  9  7  6
3  4  5  3  2
```

```python
# swap two columns (2)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data['b'], data['c']=data['c'].copy(), data['b'].copy()
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  1  3  4
1  6  5  7  8
2  8  9  7  6
3  4  5  3  2
```

131

.copy()

```
Series.copy(deep=True)
DataFrame.copy(deep=True)
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# swap two columns (3)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data['b'], data['c']=data['c'], data['b'].copy()
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0     3  4
1     7  8
2     7  6
3     3  2
```

????

Q: Will this code work?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# swap two columns (4)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data['b'], data['c']=data['c'].copy(), data['b']
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0     3  4
1     7  8
2     7  6
3     3  2
```

????

Q: Will this code work?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# swap two columns (5)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data[['b','c']]=data[['c','b']]
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  1  3  4
1  6  5  7  8
2  8  9  7  6
3  4  5  3  2
```

131

[ ] fancy indexing does not match labels.

Interesting...

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# swap two columns (6)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data[['b','c']]=data.loc[:,['c','b']]
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  1  3  4
1  6  5  7  8
2  8  9  7  6
3  4  5  3  2
```

131

[ ] fancy indexing does not match labels.

Interesting...

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# Another wrong answer to swap to columns
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.loc[:,['b','c']]=data.loc[:,['c','b']]
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

1. Select data via []
2. Select data via .loc or .iloc

.loc and .iloc will match labels

Q: How to remove the label?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```python
# Another wrong answer to swap to columns
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.loc[:,['b','c']]=data[['c','b']]
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

1. Select data via []
2. Select data via .loc or .iloc

.loc and .iloc will match labels

Q: How to remove the label?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```python
# swap two columns (7)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.loc[:,['b','c']]=data.loc[:,['c','b']].values
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  1  3  4
1  6  5  7  8
2  8  9  7  6
3  4  5  3  2
```

131

1. Select data via []
2. Select data via .loc or .iloc

.loc and .iloc will match labels

DataFrame.values will remove the labels.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# swap two columns (8)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.loc[:,['b','c']]=data[['c','b']].values
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  2  1  3  4
1  6  5  7  8
2  8  9  7  6
3  4  5  3  2
```

131

1. Select data via []
2. Select data via .loc or .iloc

.loc and .iloc will match labels

DataFrame.values will remove the labels.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Summary:

Use one command to swap two **columns** using column labels in `data`.

```
1. data['b'], data['c']=data['c'].copy(), data['b'].copy()
2. data['b'], data['c']=data['c'], data['b'].copy()
3. data[['b','c']]=data[['c','b']].copy()
4. data[['b','c']]=data.loc[:,['c','b']].copy()
5. data.loc[:,['b','c']]=data.loc[:,['c','b']].values.copy()
6. data.loc[:,['b','c']]=data[['c','b']].values.copy()
```

131

Dr. Z: ⇨Better to use **`.copy()`**.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

How about rows?

Use one command to swap two **rows** in `data`.

1. **Label-based indexing/slicing**

```
data.loc[[0,1],:]=data.loc[[1,0],:].values.copy()
```

2. **Position-based indexing/slicing**

```
data.iloc[[0,1],:]=data.iloc[[1,0],:].values.copy()
```

Dr. Z: ⇨Better to use **`.copy()`**.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# swap two rows (1)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.loc[[0,1],:]=data.loc[[1,0],:].values
print(data)
```

132

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  5  6  7  8
1  1  2  3  4
2  9  8  7  6
3  5  4  3  2
```

133

```
# swap two rows (1)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.iloc[[0,1],:]=data.iloc[[1,0],:].values
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b  c  d  e
a
0  5  6  7  8
1  1  2  3  4
2  9  8  7  6
3  5  4  3  2
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT007: Swap two rows/columns in `data`

✓ label-based indexing

Use one command

✓ `data(:,{'b','c'})=data(:,{'c','b'})`

✓ `data{:,{'b','c'}}=data{:,{'c','b'}}`

134

× `data(:,{'b','c'})=data{:,{'c','b'}}`

Right hand side of an assignment into a table must be another table or a cell array.

× `data{:,{'b','c'}}=data(:,{'c','b'})`

The following error occurred converting from table to double:

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Swap two columns (1)

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data(:,{'b','c'})=data(:,{'c','b'})
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    0     2    1    3    4
    1     6    5    7    8
    2     8    9    7    6
    3     4    5    3    2
```

134

Swap two columns (2)

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data{:,{'b','c'}}=data{:,{'c','b'}}
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    0     2    1    3    4
    1     6    5    7    8
    2     8    9    7    6
    3     4    5    3    2
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

How about rows?

✓ label-based indexing

Use one command

✓ `data({'0','1'},:)=data({'1','0'},:)`
✓ `data{{'0','1'},:}=data{{'1','0'},:}`

135

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Swap two rows, label-based (1)

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data({'0','1'},:)=data({'1','0'},:)
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    0     5    6    7    8
    1     1    2    3    4
    2     9    8    7    6
    3     5    4    3    2
```

135

Swap two rows, label-based (2)

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
data{{'0','1'},:}=data{{'1','0'},:}
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    0     5    6    7    8
    1     1    2    3    4
    2     9    8    7    6
    3     5    4    3    2
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer Of Quantitative Finance

How about using position-based indexing?

- Swap two columns

✓ `data(:,[1,2])=data(:,[2,1])`
✓ `data{:,[1,2]}=data{:,[2,1]}`

136

- Swap two rows

✓ `data([1,2],:)=data([2,1],:)`
✓ `data{[1,2],:}=data{[2,1],:}`

137

Use one command

SMU SINGAPORE MANAGEMENT UNIVERSITY

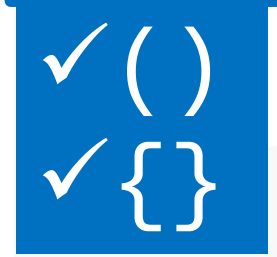
QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Use temp

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
temp=data(1,:);
data(1,:)=data(2,:);
data(2,:)=temp
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    0     5    6    7    8
    1     1    2    3    4
    2     9    8    7    6
    3     5    4    3    2
```



138

Use deal

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
[data(1,:),data(2,:)]=deal(data(2,:), data(1,:))
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    0     5    6    7    8
    1     1    2    3    4
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e
          _    _    _    _
    0     5    6    7    8
    1     1    2    3    4
    2     9    8    7    6
    3     5    4    3    2
```

139

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT008: Apply a function to each row/column of **`data`**

pandas.DataFrame.apply

`DataFrame.apply(`*func, axis=0, broadcast=None, raw=False, reduce=None, result_type=None, args=(), **kwds*`)` [source]

Apply a function along an axis of the DataFrame.

Objects passed to the function are Series objects whose index is either the DataFrame's index (`axis=0`) or the DataFrame's columns (`axis=1`). By default (`result_type=None`), the final return type is inferred from the return type of the applied function. Otherwise, it depends on the *result_type* argument.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#A Numpy universal function
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.apply(np.sqrt)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

a	b	c	d	e
0	1.000000	1.414214	1.732051	2.000000
1	2.236068	2.449490	2.645751	2.828427
2	3.000000	2.828427	2.645751	2.449490
3	2.236068	2.000000	1.732051	1.414214

140

1. Using a Numpy universal function, **`fun`**, (in the case same as **`np.fun(data)`**)

Dr. Z: How about `math.sqrt`?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#A reducing function, axis=0
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.apply(np.sum,axis=0)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2

b    20
c    20
d    20
e    20
dtype: int64
```

2. Using a reducing function on either axis

141

axis=0

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#A reducing function, axis=1
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.apply(np.sum,axis=1)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2

a
0    10
1    26
2    30
3    14
dtype: int64
```

2. Using a reducing function on either axis

142

axis=1

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#using a user-defined function, axis=0, return a single number
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.apply(lambda x: x[0]**2+np.sum(x),axis=0)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2

b    21
c    24
d    29
e    36
dtype: int64
```

3. Using a user-defined function

143

axis=0

The function returns a single value.

Dr. Z: Can I use sum( )?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#using a user-defined function, axis=1, return a list
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.apply(lambda x: [x['d']**2, x['c']**2+np.sum(x)],axis=1)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2

a
0      [9, 14]
1     [49, 62]
2     [49, 94]
3      [9, 30]
dtype: object
```

3. Using a user-defined function

144

axis=1

The function returns a list.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#using a user-defined function, axis=1, return a list, result_type='expand'
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.apply(lambda x: [x['d']**2, x['c']**2+sum(x)],
                                axis=1, result_type='expand')
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

```
    0   1
a
0   9  14
1  49  62
2  49  94
3   9  30
```

3. Using a user-defined function

145

The function returns a list.

Passing **`result_type='expand'`** will expand list-like results to columns of a DataFrame.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#using a user-defined function, axis=1, return a Series
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
data.apply(lambda x: pd.Series([x['d']**2, x['c']**2+sum(x)],
                               index=['d**2', 'c**2+sum']),
                               axis=1)
```

	b	c	d	e
a				
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

a	d**2	c**2+sum
0	9	14
1	49	62
2	49	94
3	9	30

3. Using a user-defined function

146

The function returns a list.

Returning a **Series** inside the function is similar to passing `result_type='expand'`. The resulting column names will be the Series index.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Homework Question:

dataset01.csv - Notepad

File Edit Format View Help

```
S,K,r,q,sigma,T,c
1403,1350,0.0534,0.0118,0.26,0.102777778,80.828
1403,1375,0.0534,0.0118,0.267,0.102777778,66.084
1403,1400,0.0534,0.0118,0.231,0.102777778,45.894
1403,1425,0.0534,0.0118,0.213,0.102777778,30.955
1403,1450,0.0534,0.0118,0.198,0.102777778,19.224
```

	S	K	r	q	sigma	T	c	BS
0	1403	1350	0.0534	0.0118	0.260	0.102778	80.828	80.827847
1	1403	1375	0.0534	0.0118	0.267	0.102778	66.084	66.084173
2	1403	1400	0.0534	0.0118	0.231	0.102778	45.894	45.894142
3	1403	1425	0.0534	0.0118	0.213	0.102778	30.955	30.955446
4	1403	1450	0.0534	0.0118	0.198	0.102778	19.224	19.224057

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

1. **Use one command** with the Pandas library function **`pandas.read_csv`** to load data from the CSV file, `dataset01.csv`, using the first row as column names. Name the data as **`data`**.
2. Define a function, **`option_BS`**, which computes and returns the European call option price using the following formula:

$$c = S \cdot e^{-q \cdot T} \cdot \Phi(d_1) - K \cdot e^{-r \cdot T} \cdot \Phi(d_2)$$

where

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - q + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \text{ and } d_2 = d_1 - \sigma\sqrt{T}$$

3. **Use one command** with the Pandas library function **`pandas.DataFrame.apply`** to compute the European call option price for each row of **`data`** and add the results to **`data`** as a new column, and name this column as **BS**.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT008: Apply a function to each row/column of **data**

rowfun

R2018b

Apply function to table or timetable rows

147

Syntax

```
B = rowfun(func,A)
B = rowfun(func,A,Name,Value)
```

In **rowfun**, the number of parameters in the function should be the same as the number of columns in **A**. Each parameter denotes a column in **A**.

B is a table. To return a numeric vector instead of a table, use 'OutputFormat', 'uniform'.

varfun

Apply function to table or timetable variables

148

Syntax

```
B = varfun(func,A)
B = varfun(func,A,Name,Value)
```

In **varfun**, the function is a one-variable function. The variable denotes the whole column.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

rowfun (1)

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
rowfun(@(x1,x2,x3,x4) x1+x2+x3+x4, data)
data(:,'row_sum')=rowfun(@(x1,x2,x3,x4) x1+x2+x3+x4, data)
```

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
ans =
          Var1
          ____
    0     10
    1     26
    2     30
    3     14
data =
          b     c     d     e     row_sum
          _     _     _     _     _______
    0     1     2     3     4     10
    1     5     6     7     8     26
    2     9     8     7     6     30
    3     5     4     3     2     14
```

147

data(:,'row_sum')=

Right hand side of an assignment into a table must be another table or a cell array.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

rowfun (2)

```
data=readtable('HI001a.csv','ReadRowNames',true,'ReadVariableNames',true)
rowfun(@(x1,x2,x3,x4) x1+x2+x3+x4, data, 'OutputFormat', 'uniform')
data{:,'row_sum'}=rowfun(@(x1,x2,x3,x4) x1+x2+x3+x4, data, ...
                         'OutputFormat', 'uniform')
```

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
ans =
    10
    26
    30
    14
data =
          b     c     d     e     row_sum
          _     _     _     _     _______
    0     1     2     3     4     10
    1     5     6     7     8     26
    2     9     8     7     6     30
    3     5     4     3     2     14
```

147

data{:,'row_sum'}=

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

varfun(1)

```
data=readtable('HI001a.csv','ReadRowNames',true,'ReadVariableNames',true)
varfun(@(x) sum(x), data)
data('column_mean',:)=varfun(@(x) sum(x), data)
```

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
ans =
    Fun_b     Fun_c     Fun_d     Fun_e
    _____     _____     _____     _____
    20        20        20        20
data =
                    b      c      d      e
                    __     __     __     __
    0                1      2      3      4
    1                5      6      7      8
    2                9      8      7      6
    3                5      4      3      2
    column_mean     20     20     20     20
```

148

data('column_mean',:)=

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

varfun(2)

```
data=readtable('HI001a.csv','ReadRowNames',true,'ReadVariableNames',true)
varfun(@(x) sum(x), data, 'OutputFormat', 'uniform')
data{'column_mean',:}=varfun(@(x) sum(x), data, 'OutputFormat', 'uniform')
```

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
ans =
    20    20    20    20
data =
                  b     c     d     e
                  __    __    __    __
    0              1     2     3     4
    1              5     6     7     8
    2              9     8     7     6
    3              5     4     3     2
    column_mean   20    20    20    20
```

148

```
data{'column_mean',:}=
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Homework Question:

dataset01.csv - Notepad

File Edit Format View Help

```
S,K,r,q,sigma,T,c
1403,1350,0.0534,0.0118,0.26,0.102777778,80.828
1403,1375,0.0534,0.0118,0.267,0.102777778,66.084
1403,1400,0.0534,0.0118,0.231,0.102777778,45.894
1403,1425,0.0534,0.0118,0.213,0.102777778,30.955
1403,1450,0.0534,0.0118,0.198,0.102777778,19.224
```

data =

S	K	r	q	sigma	T	c	BS
1403	1350	0.0534	0.0118	0.26	0.10278	80.828	80.828
1403	1375	0.0534	0.0118	0.267	0.10278	66.084	66.084
1403	1400	0.0534	0.0118	0.231	0.10278	45.894	45.894
1403	1425	0.0534	0.0118	0.213	0.10278	30.955	30.955
1403	1450	0.0534	0.0118	0.198	0.10278	19.224	19.224

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

1. Load data from the CSV file, `dataset01.csv`, using the first row as column names. Name the data as **`data`**.
2. Define a function, **`option_BS`**, which computes and returns the European call option price using the following formula:

$$c = S \cdot e^{-q \cdot T} \cdot \Phi(d_1) - K \cdot e^{-r \cdot T} \cdot \Phi(d_2)$$

where

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - q + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \text{ and } d_2 = d_1 - \sigma\sqrt{T}$$

3. **Use one command** to compute the European call option price for each row of **`data`** and add the results to **`data`** as a new column, and name this column as **BS**.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT009: Basic operations on two rows/columns of **`data`**

1. row(s) *op* row(s) (with the same label)
2. row(s) *op* row(s) (with different labels)
3. column(s) *op* column(s) (with the same label)
4. column(s) *op* column(s) (with different labels)
5. row(s) *op* column(s) (??? What operation???)

op: +, -, *, /, ** (or ^)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT009: Basic operations on two rows/columns of `data`

- ✓ A row/column of a DataFrame can be a DataFrame, a Series, a Numpy 2D array or a Numpy 1D array.
- ✓ Rows/Columns of a DataFrame can be a DataFrame or a Numpy 2D array.

149

	DataFrame	Series	Numpy 2D array	Numpy 1D array
DataFrame	element-wise, aligned by labels	broadcasting, align DataFrame's column labels and Series' labels	element-wise, size must agree	use array as a row, broadcasting, element-wise, **size** must agree
Series		element-wise, aligned by labels	N.A.	element-wise, size must agree
Numpy 2D array			broadcasting, element-wise, size must agree	broadcasting
Numpy 1D array				element-wise, size must agree

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#DataFrame op row-Series (DataFrame's column labels same as Series' label)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(id(data))
print(data)
print(data.iloc[0,:])
data=data+data.iloc[0,:]
print(id(data))
data
```

150

a DataFrame *op* a row-Series

data=

```
168589128
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
b    1
c    2
d    3
e    4
Name: 0, dtype: int64
168589744
```

different id

broadcasting

	b	c	d	e
0	1	2	3	4
1	1	2	3	4
2	1	2	3	4
3	1	2	3	4

(row)

(N,)⇨(1, N)

Use one command to add the first row to every row in **data**.

a	b	c	d	e
0	2	4	6	8
1	6	8	10	12
2	10	10	10	10
3	6	6	6	6

a DataFrame (original row labels)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```python
#DataFrame op row-Series (DataFrame's column labels same as Series' label)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(id(data))
print(data)
print(data.iloc[0,:])
data.values[:,:]=data+data.iloc[0,:]
print(id(data))
data
```

```
168590080
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
b    1
c    2
d    3
e    4
Name: 0, dtype: int64
168590080
```

same id

broadcasting

	b	c	d	e
0	1	2	3	4
1	1	2	3	4
2	1	2	3	4
3	1	2	3	4

a	b	c	d	e
0	2	4	6	8
1	6	8	10	12
2	10	10	10	10
3	6	6	6	6

Use one command to add the first row to every row in **data**.

× data.values=

✓ **data.values[:,:]=**

```python
#assignment: DataFraem->2D array
%reset -f
import pandas as pd
import numpy as np
x=np.ones((3,3))
print(x)
df=pd.DataFrame(np.zeros((3,3)))
print(df)
x[:,:]=df #or df.values
x
```

```
[[1. 1. 1.]
 [1. 1. 1.]
 [1. 1. 1.]]
     0    1    2
0  0.0  0.0  0.0
1  0.0  0.0  0.0
2  0.0  0.0  0.0

array([[0., 0., 0.],
       [0., 0., 0.],
       [0., 0., 0.]])
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#DataFrame op Series (DataFrame's column labels same as Series' label)
import pandas as pd
data=pd.read_csv('HT001b.csv', index_col=0, header=0)
print(data)
print(data.iloc[0,:])
data+data.iloc[0,:]
```

```
   b  a.1  d e  1
a
2  1    2    3  4
4  5    6    7  8
3  9    8    7  6
4  5    4    3  2
```

```
b      1
a.1    2
d e    3
1      4
Name: 2, dtype: int64
```

broadcasting

	b	a.1	d e	1
2	1	2	3	4
4	1	2	3	4
3	1	2	3	4
4	1	2	3	4

a	b	a.1	d e	1
2	2	4	6	8
4	6	8	10	12
3	10	10	10	10
4	6	6	6	6

150

a DataFrame *op* a row-Series

(row)

(N,) ⇨ (1, N)

Use one command to add the first row to every row in **`data`**.

a DataFrame (original row labels)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#DataFrame op 1D array (or list)
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
#arr=range(4)
arr=np.arange(4)
print(arr)
data+arr
```

151

a DataFrame *op* 1D array

(or list)

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
[0 1 2 3]
```

broadcasting

```
[[0 1 2 3]
 [0 1 2 3]
 [0 1 2 3]
 [0 1 2 3]]
```

a	b	c	d	e
0	1	3	5	7
1	5	7	9	11
2	9	9	9	9
3	5	5	5	5

a DataFrame (original row labels)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

a	b	a.1	d	e	1
2	1	2	3	4	
4	5	6	7	8	
3	9	8	7	6	
4	5	4	3	2	

152

a	b	a.1	d	e	1
2	2	3	4	5	
4	10	11	12	13	
3	18	17	16	15	
4	10	9	8	7	

Use one command to add the first column to every column in **`data`**.

numpy.tile

× `data+data.iloc[:,0]`

? `data+data.iloc[:,0].values`

× `data+data.iloc[:,0].values.reshape(4,1)`

✓ `data+np.tile(data.iloc[:,0].values.reshape(4,1),4)`

✓ `data+np.tile(data.iloc[:,[0]].values,4)`

✓ `data.apply(lambda x: x+data.iloc[:,0].values, axis=0)`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

https://docs.scipy.org/doc/numpy-1.15.0/reference/generated/numpy.tile.html

```
#Examples of numpy.tile
import numpy as np
print(np.tile([1,2],2))
print(np.tile([1,2],(2,3)))
```

```
[1 2 1 2]
[[1 2 1 2 1 2]
 [1 2 1 2 1 2]]
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Numpy Array Arithmetic Operations

153

$1 \leq M_1 < M_2; 1 \leq N_1 < N_2$

- ✓ $(M_1,)$ 1D array *op* $(M_1,)$ 1D array ⇨ $(M_1,)$ 1D array
  - × $(M_1,)$ 1D array *op* $(M_2,)$ 1D array
- ✓ (M_1, N_1) 2D array *op* (M_1, N_1) 2D array ⇨ (M_1, N_1) 2D array
  - × (M_1, N_1) 2D array *op* (M_1, N_2) 2D array
  - × (M_1, N_1) 2D array *op* (M_2, N_1) 2D array
- ✓ $(M_1, 1)$ 2D array *op* $(1, N_1)$ 2D array ⇨ (M_1, N_1) 2D array
- ✓ (M_1, N_1) 2D array *op* $(M_1, 1)$ 2D array ⇨ (M_1, N_1) 2D array
- ✓ (M_1, N_1) 2D array *op* $(1, N_1)$ 2D array ⇨ (M_1, N_1) 2D array
- ✓ (M_1, N_1) 2D array *op* $(N_1,)$ 1D array ⇨ (M_1, N_1) 2D array
  - × (M_1, N_2) 2D array *op* $(M_1,)$ 1D array

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```python
#Test Numpy Array Arithmetic Operations
import numpy as np
A=[(3,), (3,), (3,4), (3,3), (3,3), (3,4), (3,4), (3,4), (3,4)]
B=[(3,), (4,), (3,4), (3,4), (4,3), (3,1), (1,4), (4,), (3,)]
for i in range(9):
    print("-----", A[i], "+", B[i], "-----")
    array1=np.zeros(A[i])
    array2=np.zeros(B[i])
    try:
        r=array1+array2
    except:
        print("Error.")
    else:
        print(r.shape)
```

```
----- (3,) + (3,) -----
(3,)
----- (3,) + (4,) -----
Error.
----- (3, 4) + (3, 4) -----
(3, 4)
----- (3, 3) + (3, 4) -----
Error.
----- (3, 3) + (4, 3) -----
Error.
----- (3, 4) + (3, 1) -----
(3, 4)
----- (3, 4) + (1, 4) -----
(3, 4)
----- (3, 4) + (4,) -----
(3, 4)
----- (3, 4) + (3,) -----
Error.
```


SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
#What is the output? (DataFrame+1D array)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data.iloc[[0],:])
print(data.iloc[:,3].values)
data.iloc[[0],:]+data.iloc[:,3].values
```

```
   b  c  d  e
a
0  1  2  3  4
[4 8 6 2]
```

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

DataFrame+1D array

What is the output?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```python
#What is the output? (Series + Series, different labels)
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data.iloc[0,:])
print(data.iloc[:,3])
data.iloc[0,:]+data.iloc[:,3]
```

```
b    1
c    2
d    3
e    4
Name: 0, dtype: int64
a
0    4
1    8
2    6
3    2
Name: e, dtype: int64
```

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

Series+Series

What is the output?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
# How to calculate ...
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
print(data.iloc[1:,[0]])
print(data.iloc[:-1,1].values)
data.iloc[1:,[0]]+data.iloc[:-1,1].values
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
   b
a
1  5
2  9
3  5
[2 6 8]
```

DataFrame+1D array

calculate ⇨ use array (label free)

What is the output?

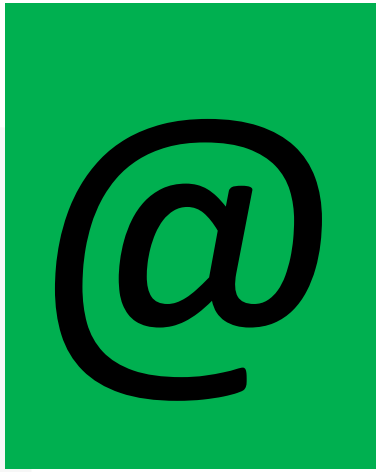
SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Matrix Multiplication using Numpy 1D/2D arrays

(M, N) 2D array
or
(N,) 1D array used
as (1,N) 2D array



(N, P) 2D array
or
(N,) 1D array used
as (N,1) 2D array

A	B	A @ B
(M, N)	(N, P)	(M, P)
(M, N)	(N, 1)	(M, 1)
(M, N)	(N,)	(M,)
(1, N)	(N, P)	(1, P)
(N,)	(N, P)	(P,)
(1, N)	(N, 1)	(1, 1)
(N,)	(N,)	()

154

```
A=np.array([[1,2,3]])
B=np.array([[1],[2],[3]])
A@B
```

```
array([[14]])
```

```
A=np.array([1,2,3])
B=np.array([1,2,3])
A@B
```

```
14
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

	b	c	d	e
a				
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

$$\begin{pmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 8 & 7 & 6 \end{pmatrix} \times \begin{pmatrix} 5 \\ 4 \\ 3 \\ 2 \end{pmatrix}$$

(3,4) (4,1)

155

Use one command to compute the matrix multiplication, using the first 3 rows in **`data`** as the first matrix, and using the last row (without finding the number of rows) as the second 1-column matrix.

```
✓ data.values[:3] @ data.values[-1]
✓ data.values[:3] @ data.values[-1:].T
✓ data.values[:3] @ data.values[[-1]].T
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT009: Basic operations on two rows/columns of **`data`**

- ✓ MATLAB tables do not support arithmetic operations.

HAHAHA....
HAHAHA....

- ✓ Using the dot syntax (⇨1-column 2D array) or **{}**-indexing, we obtain MATLAB arrays.

156

- ✓ 1D arrays are row matrices (or 1-row 2D arrays).
- ✓ Matrix dimensions must agree or one is a scalar.
- ✓ Manual broadcasting

Wow~~~

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
```

1. Add the first row to every row.
2. “help repmat”
3. “help size”

Use one command

```
data =
          b     c     d     e
          __    __    __    __
    0     2     4     6     8
    1     6     8    10    12
    2    10    10    10    10
    3     6     6     6     6
```

157

```
data{:,:}=data{:,:}+repmat(data{1,:},size(data,1),1)
```

numpy.tile(A, (M, N)) ⇔ **repmat(A, M, N)**

or **repmat(A, [M, N])**

https://www.mathworks.com/help/matlab/ref/repmat.html

https://www.mathworks.com/help/matlab/ref/size.html

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
```

- ✓ Use one command to add the first row and last column (without using the size of **`data`**) of **`data`** elementwise and return the result in a column array.
- ✓ "help transpose"
- ✓ "help end"

```
ans =
     5
    10
     9
     6
```

158

```
transpose(data{1,:})+data{:,end}
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
```

- ✓ Use one command to add elements in the first column from the second row to the last row (without using the size of **`data`**) and elements in the second column from the first row to the second to the last row (without finding the size of **`data`**) element wise and return the result in a row array.

```
ans =
     7    15    13
```

159

```
transpose(data{2:end,1}+data{1:end-1,2})
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

MATLAB Operators

X*Y : matrix multiplication

X.*Y : element-wise multiplication

X^Y : matrix power

X.^Y : element-wise power

X/Y : matrix right division

X./Y : element-wise divide

160

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
data =
          b     c     d     e
          _     _     _     _
    0     1     2     3     4
    1     5     6     7     8
    2     9     8     7     6
    3     5     4     3     2
```

$$\begin{pmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 8 & 7 & 6 \end{pmatrix} \times \begin{pmatrix} 5 \\ 4 \\ 3 \\ 2 \end{pmatrix}$$

(3,4) (4,1)

Use one command to compute the matrix multiplication, using the first 3 rows in **`data`** as the first matrix, and using the last row (without using the size of **`data`**) as the second 1-column matrix.

161

```
data{1:3, :}*transpose(data{end,:})
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT010: Sort **`data`** using a row/column

pandas.DataFrame.sort

DEPRECATED

`DataFrame.sort(columns=None, axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last', **kwargs)` [source]

DEPRECATED: use DataFrame.sort_values()

Sort DataFrame either by labels (along either axis) or by the values in column(s)

pandas.DataFrame.sort_values

`DataFrame.sort_values(by, axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')` [source]

Sort by the values along either axis

by : *str or list of str*

Name or list of names to sort by.

- if *axis* is 0 or *'index'* then *by* may contain index levels and/or column labels
- if *axis* is 1 or *'columns'* then *by* may contain column levels and/or index labels

Changed in version 0.23.0: Allow specifying index or column level names.

axis : *{0 or 'index', 1 or 'columns'}, default 0*

Axis to be sorted

numpy.sort

numpy.sort(*a, axis=-1, kind='quicksort', order=None*)

Return a sorted copy of an array.

numpy.ndarray.sort

ndarray.sort(*axis=-1, kind='quicksort', order=None*)

Sort an array, in-place.

Returns: **index_array** : *ndarray, int*

Array of indices that sort *a* along the specified axis. In other words, `a[index_array]` yields a sorted *a*.

numpy.argsort

numpy.argsort(*a, axis=-1, kind='quicksort', order=None*) [source]

Returns the indices that would sort an array.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
print(data.sort_values(by='b',axis=0))
print(data.sort_values(by=['b','c'],axis=0))
print(np.sort(data,axis=0))
print(data)
data.values.sort(axis=0)
print(data)
```

```
[[1 2 3 2]
 [5 4 3 4]
 [5 6 7 6]
 [9 8 7 8]]
```

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
3	5	4	3	2
2	9	8	7	6

a	b	c	d	e
0	1	2	3	4
3	5	4	3	2
1	5	6	7	8
2	9	8	7	6

a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2

a	b	c	d	e
0	1	2	3	2
1	5	4	3	4
2	5	6	7	6
3	9	8	7	8

inplace

- **np.sort** sort **every** row/colum.
- **np.ndarray.sort** sort, **inplace**, **every** row/colum.

pandas.DataFrame.sort_values: Sort **data** using rows/columns.

Use one command to sort rows in ascending order using the 3rd column?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
I=np.argsort(data.values,axis=0)
print(I)
print(data.values[I[:,2],:])
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
[[0 0 0 3]
 [1 3 3 0]
 [3 1 1 2]
 [2 2 2 1]]
[[1 2 3 4]
 [5 4 3 2]
 [5 6 7 8]
 [9 8 7 6]]
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

Numpy ndarray: sort rows using the 3rd column.

162

Use one command?

```
import pandas as pd
import numpy as np
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
I=np.argsort(data.values,axis=1)
print(I)
print(data.values[:,I[2,:]])
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
[[0 1 2 3]
 [0 1 2 3]
 [3 2 1 0]
 [3 2 1 0]]
[[4 3 2 1]
 [8 7 6 5]
 [6 7 8 9]
 [2 3 4 5]]
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

Numpy ndarray: sort columns using the 3rd row.

Use one command?

HT010: Sort `data` using a row/column

✓ **`sort`** (total row/column sort)

✓ **`sortrows`** (sort rows)

`sort` and `sortrows` are functions on matrices. `sort` does not work on table, `sortrows` works on table.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>> help sort
 sort   Sort in ascending or descending order.
    For vectors, sort(X) sorts the elements of X in ascending order.
    For matrices, sort(X) sorts each column of X in ascending order.
    For N-D arrays, sort(X) sorts along the first non-singleton
    dimension of X. When X is a cell array of strings, sort(X) sorts
    the strings in ASCII dictionary order.

    Y = sort(X,DIM,MODE)
    has two optional parameters.
    DIM selects a dimension along which to sort.
    MODE selects the direction of the sort
       'ascend' results in ascending order
       'descend' results in descending order
    The result is in Y which has the same shape and type as X.

    [Y,I] = sort(X,DIM,MODE) also returns an index matrix I.
    If X is a vector, then Y = X(I).
    If X is an m-by-n matrix and DIM=1, then
        for j = 1:n, Y(:,j) = X(I(:,j),j); end
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>> x=[1 2 3;3 1 2;2 1 3]
x =
     1     2     3
     3     1     2
     2     1     3
>> [y,I]=sort(x,1,'ascend')
y =
     1     1     2
     2     1     3
     3     2     3
I =
     1     2     2
     3     3     1
     2     1     3
```

```
>> x(I(:,2),:)
ans =
     3     1     2
     2     1     3
     1     2     3
```

x(I(:,2),:) sort **x** using the second column.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>> x
x =
     1     2     3
     3     1     2
     2     1     3
>> [y,I]=sort(x,2,'ascend')
y =
     1     2     3
     1     2     3
     1     2     3
I =
     1     2     3
     2     3     1
     2     1     3
```

```
>> x(:,I(2,:))
ans =
     2     3     1
     1     2     3
     1     3     2
```

x(:,I(2,:)) sort **x** using the second row.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

⇨How to use **sort** to sort **data**?

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
```

```
[y,I]=sort(data{:,:},1,'ascend')
```

```
y =
     1     2     3     2
     5     4     3     4
     5     6     7     6
     9     8     7     8
I =
     1     1     1     4
     2     4     4     1
     4     2     2     3
     3     3     3     2
```

```
data(I(:,2),:)
```

```
ans =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    3     5    4    3    2
    1     5    6    7    8
    2     9    8    7    6
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>> help sortrows
 sortrows Sort rows in ascending order.
    Y = sortrows(X) sorts the rows of the matrix X in ascending order as a
    group. X is a 2-D numeric or char matrix. For a char matrix containing
    strings in each row, this is the familiar dictionary sort.  When X is
    complex, the elements are sorted by ABS(X). Complex matches are further
    sorted by ANGLE(X).  X can be any numeric or char class. Y is the same
    size and class as X.

    sortrows(X,COL) sorts the matrix based on the columns specified in the
    vector COL.  If an element of COL is positive, the corresponding column
    in X will be sorted in ascending order; if an element of COL is negative,
    the corresponding column in X will be sorted in descending order. For
    example, sortrows(X,[2 -3]) sorts the rows of X first in ascending order
    for the second column, and then by descending order for the third
    column.
```

sortrows(X)⇔sortrows(X,1:size(X,2))

163

```
    [Y,I] = sortrows(X) and [Y,I] = sortrows(X,COL) also returns an index
    matrix I such that Y = X(I,:).
```

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>> x=[1 3 2;2 1 3;1 2 3]
x =
     1     3     2
     2     1     3
     1     2     3
>> sortrows(x)
ans =
     1     2     3
     1     3     2
     2     1     3
>> sortrows(x,[1,-2])
ans =
     1     3     2
     1     2     3
     2     1     3
```

```
>> sortrows(x,2)
ans =
     2     1     3
     1     2     3
     1     3     2
```

`sortrows(x,2)` sort **`x`** using the second column.

Q: How to use **`sortrows`** to sort **`x`** using the second row?
[Hint: `transpose(x)`]

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>> x=[1 3 2;2 1 3;1 2 3]
x =
     1     3     2
     2     1     3
     1     2     3
>> transpose(sortrows(transpose(x),2))
ans =
     3     1     2
     1     2     3
     2     1     3
```

Use **sortrows** to sort **x** using the second row?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

⇨How to use **sortrows** to sort **data**?

Use sortrows to sort data

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
```

```
[y,I]=sortrows(data,2);
data(I,:)
```

```
ans =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    3     5    4    3    2
    1     5    6    7    8
    2     9    8    7    6
```

```
[y,I]=sortrows(data,2)
```

```
y =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    3     5    4    3    2
    1     5    6    7    8
    2     9    8    7    6
I =
     1
     4
     2
     3
```

164

Use **sortrows** to sort **data** using a row?

Use one command?

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Use `sortrows` to sort `data` using the 3nd row

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
```

```
[y,I]=sortrows(transpose(data{:,:}),3);
data(:,I)
```

```
ans =
          e    d    c    b
          _    _    _    _
    0     4    3    2    1
    1     8    7    6    5
    2     6    7    8    9
    3     2    3    4    5
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Indexing on Assignment

When assigning values from one matrix to another matrix, you can use any of the styles of indexing covered in this section. Matrix assignment statements also have the following requirement.

In the assignment `A(J,K,...) = B(M,N,...)`, subscripts `J, K, M, N`, etc. may be scalar, vector, or array, provided that all of the following are true:

- The number of subscripts specified for `B`, not including trailing subscripts equal to 1, does not exceed `ndims(B)`.
- The number of nonscalar subscripts specified for `A` equals the number of nonscalar subscripts specified for `B`. For example, `A(5, 1:4, 1, 2) = B(5:8)` is valid because both sides of the equation use one nonscalar subscript.
- The order and length of all nonscalar subscripts specified for `A` matches the order and length of nonscalar subscripts specified for `B`. For example, `A(1:4, 3, 3:9) = B(5:8, 1:7)` is valid because both sides of the equation (ignoring the one scalar subscript `3`) use a 4-element subscript followed by a 7-element subscript.

```
x =
     1     2     3
     4     5     6
     7     8     9
```

166

x(2,:)=x(:,3)

```
x =
     1     2     3
     3     6     9
     7     8     9
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Caution: Numpy Array (Slicings are Views)


```
>>> import numpy as np
>>> x=np.arange(1,10).reshape(3,3)
>>> x
array([[1, 2, 3],
       [4, 5, 6],
       [7, 8, 9]])
>>> x[1,:]=x[:,2]
>>> x
array([[1, 2, 3],
       [3, 9, 9],
       [7, 8, 9]])
```

```
>>> import numpy as np
>>> x=np.arange(1,10).reshape(3,3)
>>> x
array([[1, 2, 3],
       [4, 5, 6],
       [7, 8, 9]])
>>> x[1,:]=x[:,2].copy()
>>> x
array([[1, 2, 3],
       [3, 6, 9],
       [7, 8, 9]])
```

(Dr. Z: Is it because the assignment is from right to left?) ……..(NO)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>>> import numpy as np
>>> x=np.arange(1,10).reshape(3,3)
>>> x
array([[1, 2, 3],
       [4, 5, 6],
       [7, 8, 9]])
>>> x[:,1]=x[2,:]
>>> x
array([[1, 7, 3],
       [4, 8, 6],
       [7, 9, 9]])
```

```
>>> import numpy as np
>>> x=np.arange(1,10).reshape(3,3)
>>> x
array([[1, 2, 3],
       [4, 5, 6],
       [7, 8, 9]])
>>> x[:,1]=x[2,:].copy()
>>> x
array([[1, 7, 3],
       [4, 8, 6],
       [7, 9, 9]])
```

(Dr. Z: it seems not.)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[0,:]=x[:,8]  **********
[[ 8 18 28 38 48 58 68 78 88 98]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[1,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [ 8 88 28 38 48 58 68 78 88 98]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[2,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [ 8 18 88 38 48 58 68 78 88 98]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[3,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [ 8 18 28 88 48 58 68 78 88 98]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[4,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [ 8 18 28 38 88 58 68 78 88 98]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
```

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
**********  x[5,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [ 8 18 28 38 48 88 68 78 88 98]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[6,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [ 8 18 28 38 48 58 88 78 88 98]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[7,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [ 8 18 28 38 48 58 68 88 88 98]
 [80 81 82 83 84 85 86 87 88 89]
 [90 91 92 93 94 95 96 97 98 99]]
```

```
**********  x[8,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [ 8 18 28 38 48 58 68 78 88 98]
 [90 91 92 93 94 95 96 97 98 99]]
**********  x[9,:]=x[:,8]  **********
[[ 0  1  2  3  4  5  6  7  8  9]
 [10 11 12 13 14 15 16 17 18 19]
 [20 21 22 23 24 25 26 27 28 29]
 [30 31 32 33 34 35 36 37 38 39]
 [40 41 42 43 44 45 46 47 48 49]
 [50 51 52 53 54 55 56 57 58 59]
 [60 61 62 63 64 65 66 67 68 69]
 [70 71 72 73 74 75 76 77 78 79]
 [80 81 82 83 84 85 86 87 88 89]
 [ 8 18 28 38 48 58 68 78 88 98]]
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

Dissection of the MATLAB code:

168

```
*   1 -  clear;
    2 -  clc;
    3 -  figure('Name','Figure 1', 'units','inch','position',[1.5,1.5,12,8]);
*   4 -  data=readtable('CC3.SI.csv');
1   5 -  data(data.Volume==0,:)=[];
    6 -  X=datetime(data.Date);
*   7 -  Y=data.AdjClose;
2   8 -  plot(X,Y,'k-','LineWidth',1);
3   9 -  hold on;
4  10 -  ave15=round(movmean(Y,15,'Endpoints','discard'),3);
5  11 -  ave15(1:35)=[];
*  12 -  ave50=round(movmean(Y,50,'Endpoints','discard'),3);
6  13 -  daxis=X(50:end);
   14 -  paxis=Y(50:end);
*  15 -  plot(daxis,ave15,'b-');
   16 -  plot(daxis,ave50,'c-');
7  17 -  x=ave15-ave50;
8  18 -  x(x>0)=1;
   19 -  x(x<=0)=0;
9  20 -  y=diff(x); %size is reduced by 1
10 21 -  idxSell=find(y<0)+1;
   22 -  idxBuy=find(y>0)+1;
*  23 -  plot(daxis(idxBuy),paxis(idxBuy), ...
   24           'y.','MarkerSize',20,'Linewidth',1);
   25 -  plot(daxis(idxSell),paxis(idxSell), ...
   26           'r.','MarkerSize',20,'Linewidth',1);
11 27 -  legend('Adj Close', '15d', '50d', 'crossSell', 'crossBuy');
   28 -  xlabel('Date');
*  29 -  axis tight
   30 -  set(gca,'XTickLabelRotation',30)
```

- ✓ `readtable`
- ✓ MATLAB table data selection
- ✓ `plot`
- ✓ **`hold on`**
- ✓ `movmean (D.N.T.)`
- ✓ `round`
- ✓ array comparison operations
- ✓ boolean index/logical array
- ✓ delete elements
- ✓ assignment
- ✓ array arithmetic operations
- ✓ **`diff`**
- ✓ `find`
- ✓ add `legend`
- ✓ add `xlabel` and `ylabel`
- ✓ add `title`

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

HT011: Remove missing values in **`data`**.

https://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.dropna.html

pandas.DataFrame.dropna

`DataFrame.dropna(axis=0, how='any', thresh=None, subset=None, inplace=False)` [source]

Remove missing values.

See the User Guide for more on which values are considered missing, and how to work with missing data.

rmmissing

R2018b

Remove missing entries

collapse all in page

Syntax

```
R = rmmissing(A)
R = rmmissing(A,dim)
R = rmmissing( __ ,Name,Value)
[R,TF] = rmmissing( __ )
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

axis=0, how='any', thresh=None, subset=None, inplace=False

```
import pandas as pd
data=pd.read_csv('HT001c.csv', index_col=0, header=0)
print(data)
data.dropna()
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

drop

drop

drop

a	b	c	d	e
9	1.0	2.0	3.0	4.0

data

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

`axis=0, how='any', thresh=None, subset=None, inplace=False`

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

drop drop drop drop

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

drop

```
data.dropna(axis=1)
```

a
9
8
7
6

Empty DataFrame

```
data.dropna(how='all')
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

axis=0, how='any', thresh=None, subset=None, inplace=False

```
data.dropna(thresh=2)
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN

```
data.dropna(subset=['b', 'c'])
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN

a	b	c	d	e	
9	1.0	2.0	3.0	4.0	
8	5.0	6.0	NaN	NaN	2 NaN
7	9.0	NaN	7.0	NaN	2 NaN
6	NaN	NaN	NaN	NaN	4 NaN

a	b	c	d	e	
9	1.0	2.0	3.0	4.0	
8	5.0	6.0	NaN	NaN	
7	9.0	NaN	7.0	NaN	drop
6	NaN	NaN	NaN	NaN	drop

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

axis=0, how='any', thresh=None, subset=None, inplace=False

a	b	c	d	e	
9	1.0	2.0	3.0	4.0	
8	5.0	6.0	NaN	NaN	drop
7	9.0	NaN	7.0	NaN	drop
6	NaN	NaN	NaN	NaN	drop

```
data.dropna(inplace=True)
data
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0

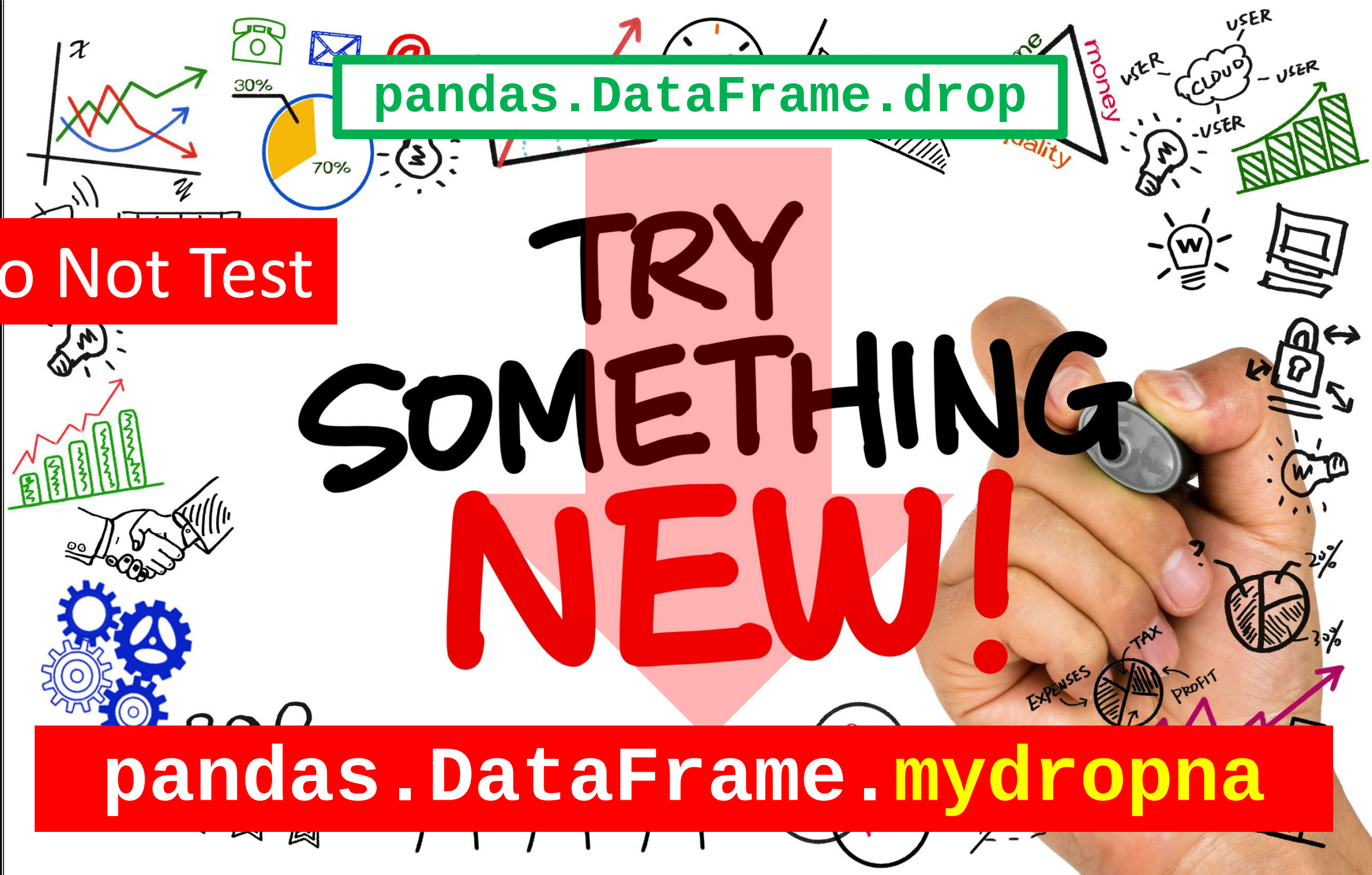
SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

pandas.DataFrame.drop

Do Not Test



pandas.DataFrame.mydropna

SMU
SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

mydropna

```
data=pd.read_csv('HT001c.csv', index_col=0, header=0)
print(data)
data.mydropna()
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

```
data
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

```
data.mydropna(axis=1)
```

a
9

```
data.mydropna(how='all
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN

```
data.mydropna(thresh=2)
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN

```
data.mydropna(subset=['b', 'c'])
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN

```
data.mydropna(inplace=True)
data
```

a	b	c	d	e
9	1.0	2.0	3.0	4.0

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
DataFrame.dropna(axis=0, how='any', thresh=None, subset=None, inplace=False)
```

```
DataFrame.mydropna(axis=0,how='any',thresh=None,subset=None,inplace=False)
```

```
DataFrame.drop(labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

axis=0

how	thresh	subset
'any'	None	None
labels=[8, 7, 6]		
'all'	None	None
labels=[6]		
'any'	2	None
labels=[6]		
'any'	None	['b','c']
labels=[7, 6]		
'any'	2	['b','c']
labels=[]		

	b	c	d	e
a				
9	1.0	2.0	3.0	4.0
8	5.0	6.0	NaN	NaN
7	9.0	NaN	7.0	NaN
6	NaN	NaN	NaN	NaN

?How to count the number of NaN.

?How to get a subset.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
data=pd.read_csv('HT001c.csv', index_col=0, header=0)
print(data)
data.isna()
```

```
     b    c    d    e
a
9  1.0  2.0  3.0  4.0
8  5.0  6.0  NaN  NaN
7  9.0  NaN  7.0  NaN
6  NaN  NaN  NaN  NaN
```

a	b	c	d	e	
9	False	False	False	False	0
8	False	False	True	True	2
7	False	True	False	True	2
6	True	True	True	True	4

```
data.isna().sum(axis=1)
```

```
a
9    0
8    2
7    2
6    4
dtype: int64
```

- ✓DataFrame.isna()
- ✓False (0), True (1)
- ✓DataFrame.sum(axis=1)

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```python
def f(self, axis=0, how='any', thresh=None, subset=None, inplace=False):
    #self.dropna(axis=axis,how=how,thresh=thresh,subset=subset,inplace=inplace)
    if thresh==None:
        t=0
    else:
        t=thresh

    if axis==0:
        if subset==None:
            if how=='all':
                t=len(self.columns)-1
            labels=self.index[self.isna().sum(axis=1)>t]
        else:
            if how=='all':
                t=len(subset)-1
            labels=self.index[self.loc[:,subset].isna().sum(axis=1)>t]
        return self.drop(labels, axis=axis, inplace=inplace)
    else:
```

????

```python
pd.core.frame.DataFrame.mydropna=f
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

https://www.mathworks.com/help/matlab/ref/rmmissing.html

```
data=readtable('HT001c.csv')
```

```
data =
     a      b      c      d      e
    __    ____   ____   ____   ____
     9      1      2      3      4
     8      5      6    NaN    NaN
     7      9    NaN      7    NaN
     6    NaN    NaN    NaN    NaN
```

```
% *|rmmising(data)| in MATLAB R2018b*
%

rmmising(data)
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
%%
%
% *MATLAB R2016b*
%
data=readtable('HT001c.csv')
```

```
%%
%
isnan(data{:,:})
```

```
%%
%
any(isnan(data{:,:}),2)
```

```
%%
%
data(any(isnan(data{:,:}),2),:)=[]
```

```
data =
     a      b      c      d      e
    _      _      _      _      _
    9      1      2      3      4
    8      5      6    NaN    NaN
    7      9    NaN      7    NaN
    6    NaN    NaN    NaN    NaN
ans =
     0     0     0     0     0
     0     0     0     1     1
     0     0     1     0     1
     0     1     1     1     1
ans =
     0
     1
     1
     1
data =
     a      b      c      d      e
    _      _      _      _      _
    9      1      2      3      4
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

pandas.DataFrame.where and pandas.DataFrame.mask

pandas.DataFrame.where

DataFrame.**where**(*cond*, *other=nan*, *inplace=False*, *axis=None*, *level=None*, *errors='raise'*, *try_cast=False*, *raise_on_error=None*) [source]

Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.

pandas.DataFrame.mask

DataFrame.**mask**(*cond*, *other=nan*, *inplace=False*, *axis=None*, *level=None*, *errors='raise'*, *try_cast=False*, *raise_on_error=None*) [source]

Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

```
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
4 -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
      A     B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True
```

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666 Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance

DataFrame.mywhere

```
import pandas as pd
import numpy as np
def f(self, m, df1, df2, inplace=False):
```


```
pd.core.frame.DataFrame.mywhere=f

data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
print(data>5)
data.mywhere(data>5, 2*data,-data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
       b      c      d      e
a
0  False  False  False  False
1  False   True   True   True
2   True   True   True   True
3  False  False  False  False
```

	0	1	2	3
0	-1.0	-2.0	-3.0	-4.0
1	-5.0	12.0	14.0	16.0
2	18.0	16.0	14.0	12.0
3	-5.0	-4.0	-3.0	-2.0

SMU SINGAPORE MANAGEMENT UNIVERSITY

QF666
Programming and Computational Finance

Dr. Zhao Yibao
Senior Lecturer
Of Quantitative Finance