Lab Session Notebook - Returns

From Prices to Returns

In this lab we'll work the very basics of Returns - computing returns, and compounding a sequence

Let's start with a set of prices for a stock "A", in a python list:

```
prices_a = [8.70, 8.91, 8.71]
```

Recall that the return from time t to time ${t+1} is given by:

$$R_{t,t+1} = \frac{P_{t+1} - P_t}{P_t}$$

or alternately

$$R_{t,t+1} = \frac{P_{t+1}}{P_t} - 1$$

If you come from R or another language that supports vectors, you might expect something like thi

```
returns_a = prices_a[:-1]/prices_a[1:] - 1
```

However, since Python lists do not operate as vectors, that will not work, generating an error about

```
# WILL NOT WORK - THIS WILL GENERATE AN ERROR!
# prices_a[1:]/prices_a[:-1] -1
```

Instead, we can convert them to a `numpy` array. Numpy arrays *do* behave like vectors, so this works

```
import numpy as np

prices_a = np.array([8.70, 8.91, 8.71])
prices_a
```

```
array([8.7 , 8.91, 8.71])
```

```
prices_a[1:]/prices_a[:-1] - 1
```

```
array([ 0.02413793, -0.02244669])
```

Now, let's add a few more days of prices and introduce a second stock. Let's call these two stocks using raw numpy arrays, we are going to use the far more powerful Pandas DataFrame, which wrap very convenient and easy to use data structure called a DataFrame. Note how the DtaFrame has tw a row index that by default runs from 0 to 4.

```
import pandas as pd

prices = pd.DataFrame({"BLUE": [8.70, 8.91, 8.71, 8.43, 8.73],
                       "ORANGE": [10.66, 11.08, 10.71, 11.59, 12.11]})
```

```
prices
```

	BLUE	ORANGE
0	8.70	10.66
1	8.91	11.08
2	8.71	10.71
3	8.43	11.59
4	8.73	12.11

WARNING

However, because Pandas DataFrames will align the row index (in this case: 0, 1, 2, 3, 4) the exact s as you might expect. (see the section on row alignment in the "Crash Course" videos if this is uncle

```
prices.iloc[1:]
```

	BLUE	ORANGE
1	8.91	11.08
2	8.71	10.71
3	8.43	11.59
4	8.73	12.11

```
1 prices.iloc[:-1]
```

	BLUE	ORANGE
0	8.70	10.66
1	8.91	11.08
2	8.71	10.71
3	8.43	11.59

```
1 prices.iloc[1:]/prices.iloc[:-1] - 1
```

	BLUE	ORANGE
0	NaN	NaN
1	0.0	0.0
2	0.0	0.0
3	0.0	0.0
4	NaN	NaN

We can fix this in one of several ways. First, we can extract the values of the DataFrame column wl
the DataFrame does not try and align the rows.

```
1 prices.iloc[1:].values/prices.iloc[:-1] - 1
```

	BLUE	ORANGE
0	0.024138	0.039400
1	-0.022447	-0.033394
2	-0.032147	0.082166
3	0.035587	0.044866

You could have also used the values in the denominator:

```
1 prices.iloc[1:]/prices.iloc[:-1].values - 1
```

	BLUE	ORANGE
1	0.024138	0.039400
2	-0.022447	-0.033394
3	-0.032147	0.082166
4	0.035587	0.044866

However, there are a couple of ways to do this without extracting the values, and these are probabl
The first option is to use the `.shift()` method on the array, which realigns the indices.

```
1 prices
```

	BLUE	ORANGE
0	8.70	10.66
1	8.91	11.08
2	8.71	10.71
3	8.43	11.59
4	8.73	12.11

Since we want to get the row at index 0 (8.84 and 10.66) to line up with the row at index 1 (8.54 an
row (at index 1) by the first row (at index 0) we want to shift the rows in the denominator by 1 ... wh

```
1 prices.shift(1)
```

	BLUE	ORANGE
0	NaN	NaN
1	8.70	10.66
2	8.91	11.08
3	8.71	10.71
4	8.43	11.59

So, now we can obtain the returns on each day as follows:

```
returns = prices/prices.shift(1) - 1
returns
```

	BLUE	ORANGE
0	NaN	NaN
1	0.024138	0.039400
2	-0.022447	-0.033394
3	-0.032147	0.082166
4	0.035587	0.044866

Note how we cannot compute returns for the first day, because we dont have the closing price for t
one data point when we go from prices to returns.

Finally, there is a built-in method in DataFrame that computes the percent change from one row to
return is (the percent change in price) we can just use this method to compute the return.

```
returns = prices.pct_change()
returns
```

	BLUE	ORANGE
0	NaN	NaN
1	0.024138	0.039400
2	-0.022447	-0.033394
3	-0.032147	0.082166
4	0.035587	0.044866

Reading data from a CSV file

Since typing in returns is tedious, let's read the data in from a file. Pandas provides a convenient ar
the returns.

```
import os
print(f"working directory:{os.getcwd()}")
print(f"  contents:{os.listdir(os.getcwd())}")
```

```
working directory:/content
  contents:['.config', 'sample_data']
```

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_

Enter your authorization code:
··········
Mounted at /content/drive
```

```
DATAPATH = '/content/drive/My Drive/Coursera/EDHEC/investment-portfolio/data'
print(f"DATAPATH:{DATAPATH} contents:{os.listdir(DATAPATH)}")
```

```
DATAPATH:/content/drive/My Drive/Coursera/EDHEC/investment-portfolio/data cont
```

```
prices = pd.read_csv(DATAPATH + '/sample_prices.csv')
prices
```

	BLUE	ORANGE
0	8.7000	10.6600
1	8.9055	11.0828
2	8.7113	10.7100
3	8.4346	11.5907
4	8.7254	12.1070
5	9.0551	11.7876
6	8.9514	11.2078
7	9.2439	12.5192
8	9.1276	13.3624
9	9.3976	14.4080
10	9.4554	11.9837
11	9.5704	12.2718
12	9.7728	11.5892

```
returns = prices.pct_change()
returns
```

	BLUE	ORANGE
0	NaN	NaN
1	0.023621	0.039662
2	-0.021807	-0.033638
3	-0.031763	0.082232
4	0.034477	0.044544
5	0.037786	-0.026381
6	-0.011452	-0.049187
7	0.032676	0.117008
8	-0.012581	0.067353
9	0.029581	0.078249
10	0.006151	-0.168261
11	0.012162	0.024041
12	0.021149	-0.055623

```
returns.mean()
```

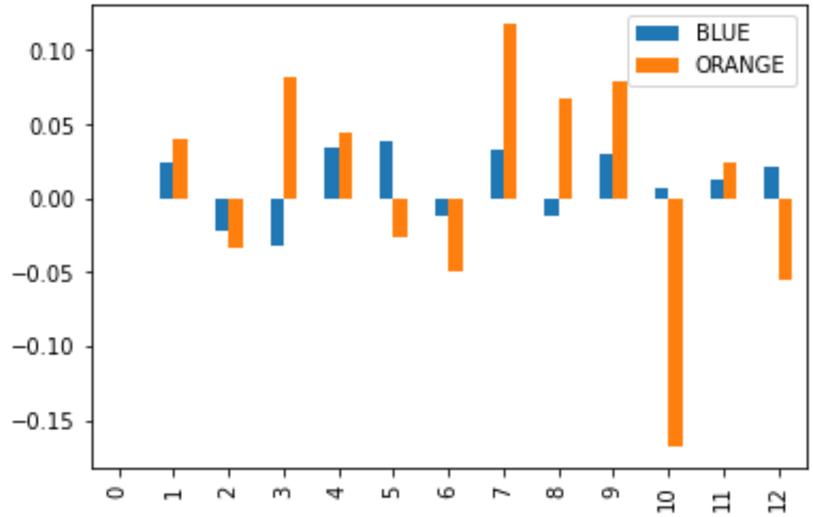
```
BLUE      0.01
ORANGE    0.01
dtype: float64
```

```
returns.std()
```

```
BLUE      0.023977
ORANGE    0.079601
dtype: float64
```

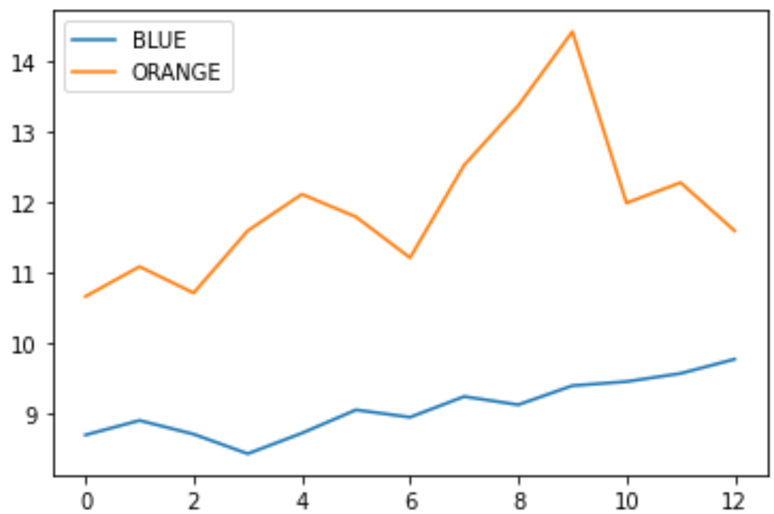
```
1 returns.plot.bar()
```

<matplotlib.axes._subplots.AxesSubplot at 0x7f1227aa5e10>




```
1 prices.plot()
```

<matplotlib.axes._subplots.AxesSubplot at 0x7f1227988438>



Compounding Returns

Now that we have a series of 12 monthly returns, we can produce the compounded return by multi|
as long as the returns are expressed as growth rates in what I call "1+R" format.

To compound the returns, all we need to do is add 1 to each return and then multiply them. The res
need to subtract 1.

Let's compute the compounded return of our two series.

```
1 returns + 1
```

	BLUE	ORANGE
0	NaN	NaN
1	1.023621	1.039662
2	0.978193	0.966362
3	0.968237	1.082232
4	1.034477	1.044544
5	1.037786	0.973619
6	0.988548	0.950813
7	1.032676	1.117008
8	0.987419	1.067353
9	1.029581	1.078249
10	1.006151	0.831739
11	1.012162	1.024041
12	1.021149	0.944377

```
1 np.prod(returns+1)
```

```
BLUE      1.123310
ORANGE    1.087167
dtype: float64
```

```
1 (returns+1).prod()
```

```
BLUE      1.123310
ORANGE    1.087167
dtype: float64
```

```
1 (returns+1).prod()-1
```

```
BLUE      0.123310
ORANGE    0.087167
dtype: float64
```

```
(((returns+1).prod()-1)*100).round(2)
```

```
BLUE      12.33
ORANGE     8.72
dtype: float64
```

Annualizing Returns

To annualize a return for a period, you compound the return for as many times as there are periods a monthly return you compund that return 12 times. The formula to annualize a monthly return R_m

$$(1 + R_m)^{12} - 1$$

To annualize a quarterly return R_q you would get:

$$(1 + R_q)^{4} - 1$$

And finally, to annualize a daily return R_d you would get:

$$(1 + R_d)^{252} - 1$$

For example, to annualize a 1% monthly, and 4% quarterly and a 0.01% daily return you would do:

```
rm = 0.01
(1+rm)**12 - 1
```

```
0.12682503013196977
```

```
rq = 0.04
(1+rq)**4 - 1
```

```
0.1698585600000002
```

```
rd = 0.0001
(1+rd)**252 - 1
```

```
0.025518911987694626
```