```
%load_ext autoreload
%autoreload 2
%matplotlib inline

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

```
import matplotlib.pyplot as plt
#%matplotlib plt.rcParams['figure.figsize'] = (12.0, 6.0)
#%matplotlib plt.rc('figure', figsize=(20.0, 10.0))

import os, sys

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

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

sys.path.append(MODULEPATH)
print(f"sys.path:{sys.path}")

import numpy as np
import pandas as pd

import edhec_risk_kit_110_BBI as erk
```

Finding the Max Sharpe Ratio Portfolio

We've already seen that given a set of expected returns and a covariance matrix, we can plot the ef
extend the code to locate the point on the efficient frontier that we are most interested in, which is
Sharpe Ratio portfolio.

Let's start by the usual imports, and load in the data.

```
#%load_ext autoreload
#%autoreload 2
#%matplotlib inline
#import edhec_risk_kit_110 as erk

ind = erk.get_ind_returns(DATAPATH)
er = erk.annualize_rets(ind["1996":"2000"], 12)
cov = ind["1996":"2000"].cov()
```

```
cov
```

We already know how to identify points on the curve if we are given a target rate of return. Instead
target return, we want to find that one point on the curve that maximizes the Sharpe Ratio, given th

```
def msr(riskfree_rate, er, cov):
    """
    Returns the weights of the portfolio that gives you the maximum sharpe ratio
    given the riskfree rate and expected returns and a covariance matrix
    """
    n = er.shape[0]
    init_guess = np.repeat(1/n, n)
    bounds = ((0.0, 1.0),) * n # an N-tuple of 2-tuples!
    # construct the constraints
    weights_sum_to_1 = {'type': 'eq',
                        'fun': lambda weights: np.sum(weights) - 1
    }
    def neg_sharpe(weights, riskfree_rate, er, cov):
        """
        Returns the negative of the sharpe ratio
        of the given portfolio
        """
        r = portfolio_return(weights, er)
        vol = portfolio_vol(weights, cov)
        return -(r - riskfree_rate)/vol

    weights = minimize(neg_sharpe, init_guess,
                       args=(riskfree_rate, er, cov), method='SLSQP',
                       options={'disp': False},
                       constraints=(weights_sum_to_1,),
                       bounds=bounds)
    return weights.x
```

Let's guess where the point might be:

```
1 import edhec_risk_kit_110_BBI as erk
2 ax = erk.plot_ef(20, er, cov)
3 ax.set_xlim(left = 0)
```

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

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

```
# plot EF
ax = erk.plot_ef(20, er, cov)
ax.set_xlim(left = 0)
```

```
# get MSR
rf = 0.1
w_msr = erk.msr(rf, er, cov)
r_msr = erk.portfolio_return(w_msr, er)
vol_msr = erk.portfolio_vol(w_msr, cov)
# add CML
cml_x = [0, vol_msr]
cml_y = [rf, r_msr]
ax.plot(cml_x, cml_y, color='green', marker='o', linestyle='dashed', linewidth=2
```

```
r_msr, vol_msr
```

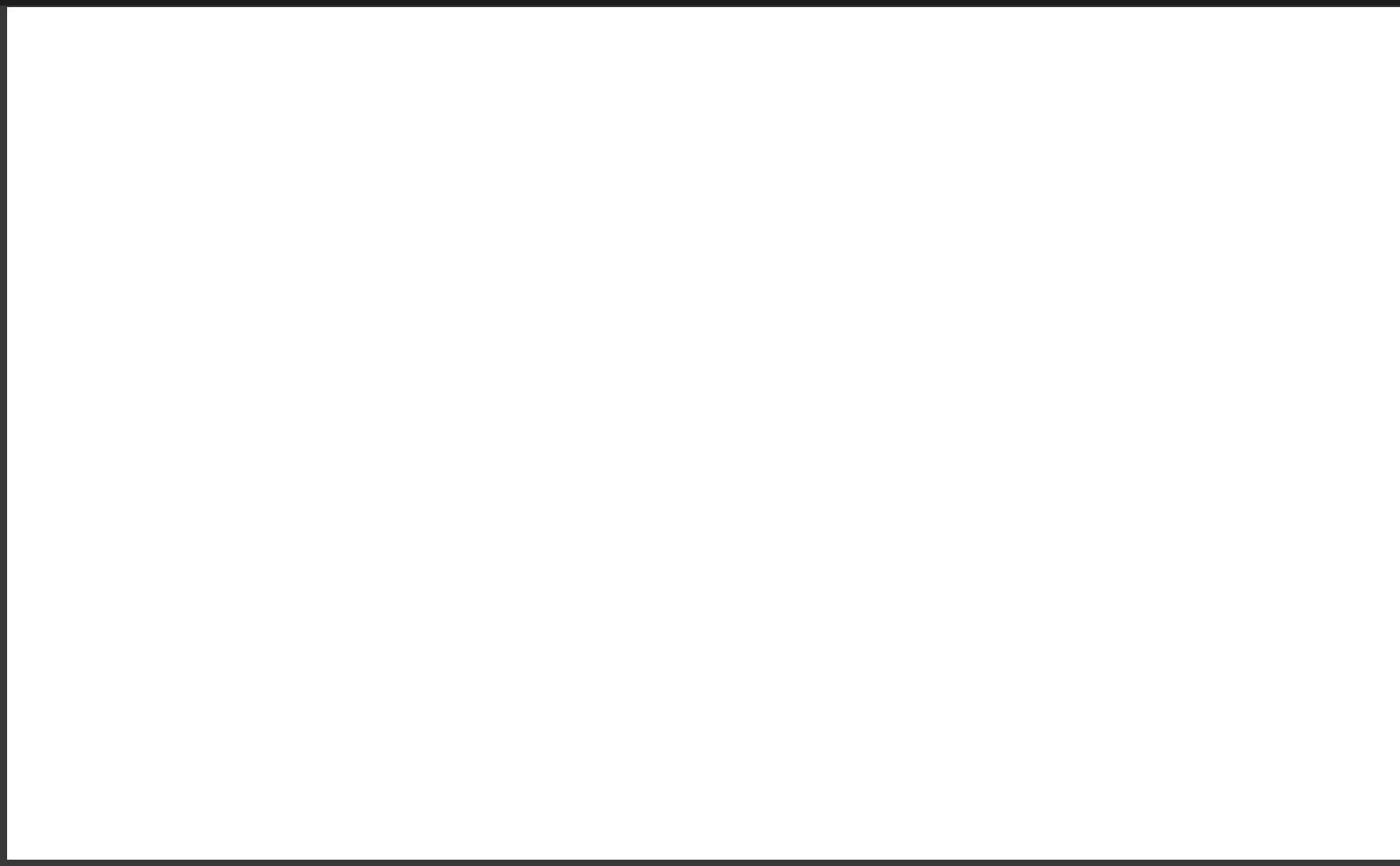
```
DATAPATH:/content/drive/My Drive/Coursera/EDHEC/investment-portfolio/data cont
```

Let's put it all together by adding the CML to the `plot_ef` code.

Add the following code:

```
    if show_cml:
        ax.set_xlim(left = 0)
        # get MSR
        w_msr = msr(riskfree_rate, er, cov)
        r_msr = portfolio_return(w_msr, er)
        vol_msr = portfolio_vol(w_msr, cov)
        # add CML
        cml_x = [0, vol_msr]
        cml_y = [riskfree_rate, r_msr]
        ax.plot(cml_x, cml_y, color='green', marker='o', linestyle='dashed', linewidth=2
```

```
1 erk.plot_ef(20, er, cov, style='-', show_cml=True, riskfree_rate=0.1)
```



```
1
```