QF600 ASSETING PRICING

HomeWork 2

In [3]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import statsmodels.api as sm
```

In [4]:
```
%whos
```

```
Variable   Type      Data/Info
------------------------------
np         module    <module 'numpy' from '/Us<...>kages/numpy/__init__.p
y'>
pd         module    <module 'pandas' from '/U<...>ages/pandas/__init__.p
y'>
plt        module    <module 'matplotlib.pyplo<...>es/matplotlib/pyplot.p
y'>
sm         module    <module 'statsmodels.api'<...>ages/statsmodels/api.p
y'>
```

Capital Asset Pricing Model (CAPM)

In [5]:
```
industry_portfolios = \
    pd\
    .read_csv("/Users/lu/Desktop/Industry_Portfolios.csv")

mkt_portfolio =\
    pd\
    .read_csv("/Users/lu/Desktop/Market_Portfolio.csv")

industry_portfolios
```

Out[5]:

	Date	NoDur	Durbl	Manuf	Enrgy	HiTec	Telcm	Shops	Hlth	Utils	Otl
0	200401	0.06	-1.07	-0.62	0.44	4.53	1.41	0.45	3.09	1.92	2
1	200402	4.25	-0.07	1.95	4.69	-2.92	-0.52	6.09	0.89	2.07	2
2	200403	-0.09	-1.15	-0.27	-0.13	-2.55	-2.07	0.29	-3.96	1.13	-0
3	200404	1.42	2.30	-0.17	2.52	-4.91	-0.48	-2.70	3.54	-3.55	-3
4	200405	-1.89	-1.64	1.61	0.39	4.85	-2.95	0.30	-0.42	1.28	1
...	...	...	...	...	...	...	...	...	...	...	
115	201308	-4.00	-1.00	-1.95	-1.83	-0.12	-3.28	-4.21	-3.49	-4.43	-3
116	201309	1.94	6.46	5.20	2.03	3.77	4.33	4.46	4.19	1.05	3
117	201310	4.75	0.72	4.56	4.86	3.80	5.52	5.08	3.47	3.35	3
118	201311	1.29	1.81	2.95	0.85	3.65	0.27	3.67	4.54	-1.81	4
119	201312	2.65	1.18	3.13	2.95	4.04	3.96	0.20	0.71	1.79	3

120 rows × 11 columns

In [6]:

```
mkt_portfolio
```

Out[6]:

	Date	Market
0	200401	2.22
1	200402	1.46
2	200403	-1.23
3	200404	-1.75
4	200405	1.23
...	...	...
115	201308	-2.69
116	201309	3.76
117	201310	4.17
118	201311	3.12
119	201312	2.81

120 rows × 2 columns

In [7]:

```
# merge two data frames

merged_data =\
    pd\
    .merge(industry_portfolios,
           mkt_portfolio,
           on='Date',
           how='inner')
```

```
merged_data
```

Out[7]:

	Date	NoDur	Durbl	Manuf	Enrgy	HiTec	Telcm	Shops	Hlth	Utils	Otl
0	200401	0.06	-1.07	-0.62	0.44	4.53	1.41	0.45	3.09	1.92	2
1	200402	4.25	-0.07	1.95	4.69	-2.92	-0.52	6.09	0.89	2.07	2
2	200403	-0.09	-1.15	-0.27	-0.13	-2.55	-2.07	0.29	-3.96	1.13	-0
3	200404	1.42	2.30	-0.17	2.52	-4.91	-0.48	-2.70	3.54	-3.55	-3
4	200405	-1.89	-1.64	1.61	0.39	4.85	-2.95	0.30	-0.42	1.28	1
...	...	...	...	...	...	...	...	...	...	...	
115	201308	-4.00	-1.00	-1.95	-1.83	-0.12	-3.28	-4.21	-3.49	-4.43	-3
116	201309	1.94	6.46	5.20	2.03	3.77	4.33	4.46	4.19	1.05	3
117	201310	4.75	0.72	4.56	4.86	3.80	5.52	5.08	3.47	3.35	3
118	201311	1.29	1.81	2.95	0.85	3.65	0.27	3.67	4.54	-1.81	4
119	201312	2.65	1.18	3.13	2.95	4.04	3.96	0.20	0.71	1.79	3

120 rows × 12 columns

Assume that the (net) risk-free rate is 0.13% per month.

In [8]:

```
risk_free_rate = 0.13
```

USING FORMULA: $\tilde{R}_i - R_f = \alpha_i + \beta_i(\tilde{R}_m - R_f)$

In [11]:

```
#R_m - R_f (mkt excess return)
merged_data["mkt_excess_returns"] =\
    merged_data["Market"]\
    -\
    risk_free_rate

merged_data
```

Out[11]:

	Date	NoDur	Durbl	Manuf	Enrgy	HiTec	Telcm	Shops	Hlth	Utils	...
0	200401	0.06	-1.07	-0.62	0.44	4.53	1.41	0.45	3.09	1.92	...
1	200402	4.25	-0.07	1.95	4.69	-2.92	-0.52	6.09	0.89	2.07	...
2	200403	-0.09	-1.15	-0.27	-0.13	-2.55	-2.07	0.29	-3.96	1.13	...
3	200404	1.42	2.30	-0.17	2.52	-4.91	-0.48	-2.70	3.54	-3.55	...
4	200405	-1.89	-1.64	1.61	0.39	4.85	-2.95	0.30	-0.42	1.28	...
...	...	...	...	...	...	...	...	...	...	...	...
115	201308	-4.00	-1.00	-1.95	-1.83	-0.12	-3.28	-4.21	-3.49	-4.43	...
116	201309	1.94	6.46	5.20	2.03	3.77	4.33	4.46	4.19	1.05	...
117	201310	4.75	0.72	4.56	4.86	3.80	5.52	5.08	3.47	3.35	...
118	201311	1.29	1.81	2.95	0.85	3.65	0.27	3.67	4.54	-1.81	...
119	201312	2.65	1.18	3.13	2.95	4.04	3.96	0.20	0.71	1.79	...

120 rows × 23 columns

In [12]:

```
# R_i - R_f(for each industry excess return)
industry_columns = ['NoDur', 'Durbl', 'Manuf', 'Enrgy', 'HiTec', 'Telcm',

for industry in industry_columns:
    merged_data\
    [f'{industry}_Excess_Returns'] =\
    merged_data[industry]\
    -\
    risk_free_rate

merged_data
```

Out[12]:

	Date	NoDur	Durbl	Manuf	Enrgy	HiTec	Telcm	Shops	Hlth	Utils	...
0	200401	0.06	-1.07	-0.62	0.44	4.53	1.41	0.45	3.09	1.92	...
1	200402	4.25	-0.07	1.95	4.69	-2.92	-0.52	6.09	0.89	2.07	...
2	200403	-0.09	-1.15	-0.27	-0.13	-2.55	-2.07	0.29	-3.96	1.13	...
3	200404	1.42	2.30	-0.17	2.52	-4.91	-0.48	-2.70	3.54	-3.55	...
4	200405	-1.89	-1.64	1.61	0.39	4.85	-2.95	0.30	-0.42	1.28	...
...	...	...	...	...	...	...	...	...	...	...	...
115	201308	-4.00	-1.00	-1.95	-1.83	-0.12	-3.28	-4.21	-3.49	-4.43	...
116	201309	1.94	6.46	5.20	2.03	3.77	4.33	4.46	4.19	1.05	...
117	201310	4.75	0.72	4.56	4.86	3.80	5.52	5.08	3.47	3.35	...
118	201311	1.29	1.81	2.95	0.85	3.65	0.27	3.67	4.54	-1.81	...
119	201312	2.65	1.18	3.13	2.95	4.04	3.96	0.20	0.71	1.79	...

120 rows × 23 columns

Table of the intercept and slope coefficients for the ten industry portfolios.

In [13]:
```
res = {}
for industry in industry_columns:
    x =\
    merged_data['mkt_excess_returns']

    y =\
    merged_data[f'{industry}_Excess_Returns']

    x =\
    sm\
    .add_constant(x)

    model =\
    sm\
    .OLS(y, x)\
    .fit()

    alpha, beta =\
    model\
    .params

    res[industry] = \
    {'Alpha': alpha,
     'Beta': beta}

res_df = \
    pd\
    .DataFrame(res)\
    .T

res_df
```

Out[13]:

	Alpha	Beta
NoDur	0.369443	0.652647
Durbl	-0.415599	1.648536
Manuf	0.159771	1.169846
Enrgy	0.501719	0.969850
HiTec	-0.064020	1.132969
Telcm	0.194691	0.900729
Shops	0.275492	0.826492
Hlth	0.237841	0.673036
Utils	0.444585	0.538086
Other	-0.387135	1.207309

Explanation

The economic significance of the intercept (α) means the abnormal performance and abnormal return of assets, the pricing implication is whether assets have a reasonable price to the market, where $\alpha > 0$ indicates Excess return and undervaluation; $\alpha < 0$ means a shortfall and overvaluation, and $\alpha = 0$ implies the asset return matches market expectations without excess return.

The slope coefficients(β) reflects sensitivity of an asset to market risk, where $\beta > 1$ means higher volatility than the market, $\beta < 1$ indicates lower volatility, $\beta = 1$ means equal volatility, and $\beta < 0$ shows inverse volatility to the market.

Security Market Line (SML)

In [24]:
```
# mean return of 10 industries portfolios and the market portfolio
mean_industry_returns =\
    merged_data[industry_columns]\
    .mean()

mean_mkt_return =\
    merged_data['Market']\
    .mean()

df = mean_industry_returns.to_frame()
df.columns = ['industry']
df
```

Out[24]:

	industry
NoDur	0.902833
Durbl	0.733333
Manuf	1.012833
Enrgy	1.231167
HiTec	0.766250
Telcm	0.881417
Shops	0.916333
Hlth	0.783833
Utils	0.907167
Other	0.489083

In [15]:
```
mean_mkt_return
```

Out[15]:
```
np.float64(0.7480833333333334)
```

In [32]:
```
all_beta = res_df["Beta"]
df["beta"] = all_beta
market_data = {'industry': mean_mkt_return, 'beta': 1}
df.loc['market'] = market_data

df
```

Out[32]:

	industry	beta
NoDur	0.902833	0.652647
Durbl	0.733333	1.648536
Manuf	1.012833	1.169846
Enrgy	1.231167	0.969850
HiTec	0.766250	1.132969
Telcm	0.881417	0.900729
Shops	0.916333	0.826492
Hlth	0.783833	0.673036
Utils	0.907167	0.538086
Other	0.489083	1.207309
market	0.748083	1.000000

In [36]:

```
X = sm.add_constant(df['beta'])
Y = df['industry']
model = sm.OLS(Y, X).fit()

intercept = model.params['const']
slope = model.params['beta']
```

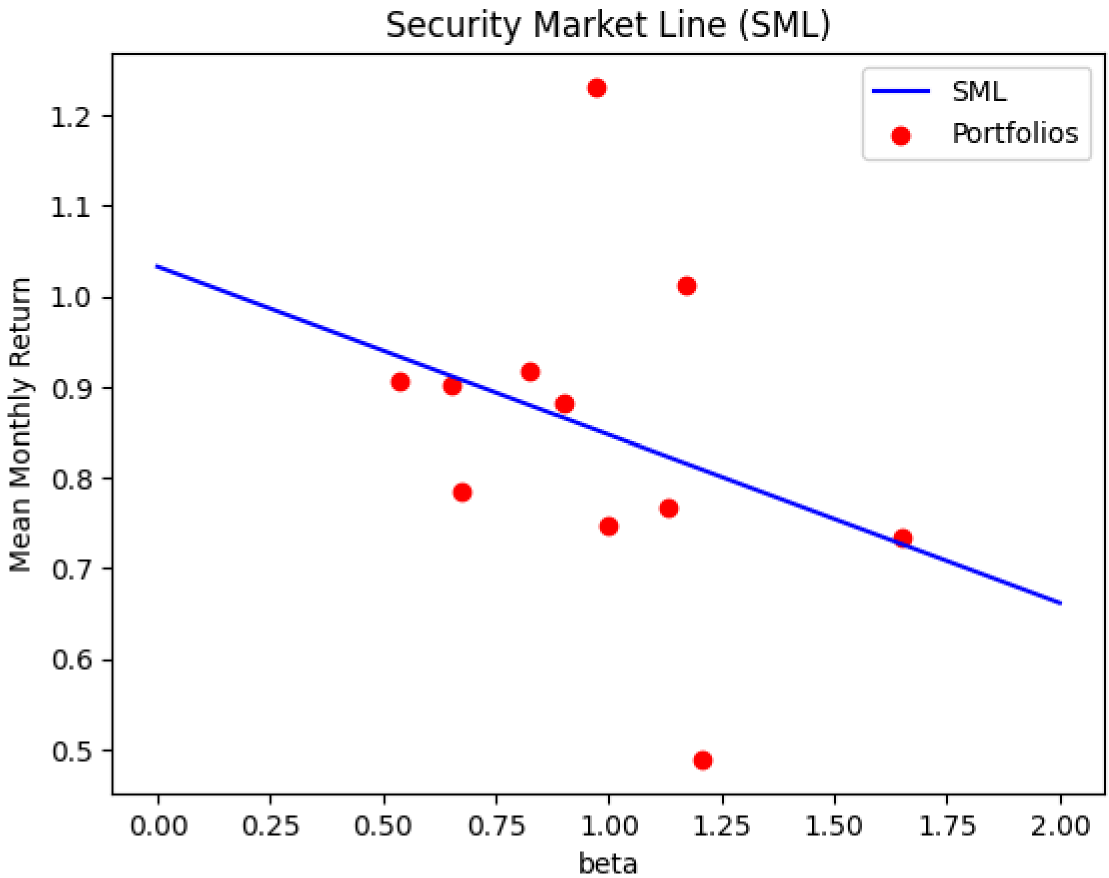
In [38]:

```
beta_range = np.linspace(0, 2, 100)
sml_values = intercept + slope * beta_range  # SML
plt.plot(beta_range, sml_values, label='SML', color='blue')


plt.scatter(df['beta'], df['industry'], color='red', label='Portfolios')


plt.xlabel('beta')
plt.ylabel('Mean Monthly Return')
plt.title('Security Market Line (SML)')
plt.legend()

plt.show()
```



Explanation

The intercept of SML represents the market risk premium, while its slope shows the return from risk-free asstes. SML measures whether assets are reasonably priced if the asset portfolio is on the SML, that means the asset is reasonably priced. If assets above SML indicate that the asset is undervalued, otherwise, it is overvalued.