**PART 2 HWK 2 (ON PORTFOLIO OPTIMIZATION)**

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**A MODIFIED VERSION OF MARKOWITZ MODERN PORTFOLIO THEORY**

**APPLIED TO THE MANAGEMENT OF STOCKS & ETF PORTFOLIOS**

**UNDER REAL MARKET CONSTRAINTS**

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WE HAVE UPLOADED markowitz\_PYOPT.rar that can execute 4 functions (4 cases):

**if case == 1:**

#1. Capital market (tangential) port (maximize sharpe ratio)

ef = EfficientFrontier(mean\_ann, covariance\_ann, weight\_bounds=(0, 1))

ef.solver = cp.CPLEX

w\_dict=ef.max\_sharpe(risk\_free\_rate=risk\_free\_rate) #annualized risk\_free

**elif case == 2:**

#2. Flipped Markowitz port (maximize sharpe ratio while setting the volatility no more than X)

ef = EfficientFrontier(mean\_ann, covariance\_ann, weight\_bounds=(0, 1))

ef.solver = cp.CPLEX

out = ef.min\_volatility() #check viability of maximum volatlity constraint

if max\_volatility < out[1]:

max\_volatility = out[1] #if the volatility of the minimum variance porfolio is larger than the contraint, replace constraint by variance of minimum variance portfolio

ef = EfficientFrontier(mean\_ann, covariance\_ann, weight\_bounds=(0, 1)) #Note: a new EfficientFrontier object should be instantiated if you want to make any change to objectives/constraints/bounds/parameters.

ef.solver = cp.CPLEX

w\_dict=ef.efficient\_risk(target\_volatility=max\_volatility) #annualized target\_volatility

**elif case == 3:**

#3. Classic Markowitz port (minimize volatility while setting required return no less than X)

ef = EfficientFrontier(mean\_ann, covariance\_ann, weight\_bounds=(0, 1))

ef.solver = cp.CPLEX

if mean.max() < req\_return: #check viability of minimum required return constraint

\_return = mean.max() #if the minimum required return is larger than the maximum expected return, replace constraint by maximum expected return

w\_dict=ef.efficient\_return(target\_return=req\_return) #annualized target\_return

**elif case == 4:**

#4. Minimum variance port (minimize volatility)

ef = EfficientFrontier(mean\_ann, covariance\_ann, weight\_bounds=(0, 1))

ef.solver = cp.CPLEX

w\_dict=ef.min\_volatility()

**NOTICE:**

1. Calculate the 3 metrics below [Sharpe Ratio, CAGR & Annualized Volatility] for the "stock market" during the period: dt.datetime(2009, 1, 30), dt.datetime(2020, 1, 30) (you can use an EXCEL spreadsheet for this).
2. For step 1, assume that the "stock market" is represented by one of its proxys -- the S&P 500 index or the Dow Jones index, your choice.
3. Do your calculations on the ETF that represents the market proxy of your choice:
   * S&P 500 = SPY ETF (price data available in Yahoo Finance)
   * <https://ca.finance.yahoo.com/quote/SPY/history?p=SPY>
   * Dow Jones Index = DIA ETF (price data available in Yahoo Finance)
   * <https://ca.finance.yahoo.com/quote/DIA/history?p=DIA>

**METRICS:**

* CAGR
* SHARPE RATIO
* ANNUALIZED STDEV

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**REMARKS:**

* If your client asks you for a portfolio with a performance superior to the “performance of the market”, as we indicated before, use as your "stock market proxy" (comparison benchmark) the S&P 500 index embodied in the spy ETF, or, alternatively, the Dow Jones index embodied in the “DIA” ETF.

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**LIST OF ASSETS THAT YOU CAN USE TO BUILD THE PORTFOLIOS**

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**Stocks Included In The Dow Jones Stocks Index:**

#StockList = ['AXP', 'AAPL', 'BA','CAT','CVX','CSCO','KO','DIS','XOM','GS', 'HD', 'IBM','INTC','JNJ','JPM','MCD','MRK','MSFT','NKE','PFE', 'PG', 'TRV','UTX','UNH', 'VZ','V','WMT','WBA']

**21 ETFS representing the 21 Industrial Sectors of the S&P 500:**

#StockList = ["FDN","IBB","IEZ","IGV","IHE","IHF","IHI","ITA","ITB","IYJ","IYT","IYW","IYZ","KBE","KCE","KIE","PBJ","PBS","SMH","VNQ"]

**10 ETFS representing the 10 Market Sectors of the S&P 500:**

#StockList = ["XLB","XLE", "XLF", "XLI", "XLK", "XLP", "XLU", "XLV", "XLY", "XTR"]

OBSERVATION: it is possible you may have to delete XTR because of incomplete data. Try to keep it BUT if it gives an error, JUST remove it.

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**USING THE PORTFOLIO MANAGEMENT SOFTWARE**

**IN 3 REAL CONSTRAINT SCENARIOS**

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Assume that you have 3 clients:

**Client A:**

* This client is quite risk-averse; requires that the annualized stdev (volatility) of his portfolio as a whole is capped at 15%, with no exceptions

**Client B**

* This client does not feel he needs a volatility cap (i.e., he is relatively risk tolerant, even though not risk indifferent), but wants and expects to have a return sufficiently close to the return of the "stock market", while keeping a fixed percentage of his capital as cash, or invested in a cash equivalent asset (cash is considered to be equivalent to the risk free asset, i.e., govt. treasury bonds).

**Client C**

* This client instead, does not need a volatility cap; he wants to have a return if possible higher than that of the "capital market portfolio", and, by the way, does not see as necessary to keep any fixed percentage of his capital in cash (cash is equivalent to the risk free asset). He has no particular risk constraint: he is the typical “risk indifferent client”.

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**REMARKS:**

* Once you design portfolios (B) and (C), you will have to compare them with “the market” to see if your clients got what they asked for; once again, this means that you should compare the performance of these portfolios with a “market proxy” (i.e., with an index that reasonably represents the market). This market proxy is called a “comparison benchmark”. You can assume the S&P 500 as your market proxy (= comparison benchmark), case in which you can use for your calculations the “SPY”, which is the ETF that best represents the S&P 500 index.

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**IMPORTANT QUESTIONS REGARDING THE EXERCISE**

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**QUESTION 1:**

**Which case (1, 2 , 3 or 4) would you run for which client?** Select and run a function for each client and make sure you jot down the 3 metrics (CAGR, Sharpe Ratio & annualized STDEV) for **the equity curve of the resulting portfolio** after running the software.

**QUESTION 2:**

**Were you able to meet the various client specifications with the software provided?** Please see DELIVERABLES.

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**REMARKS:**

* These programs are (of course) subject to be modified and/or improved upon by you.
* Use only stocks with complete price histories and no NANs (not-a-number values) to avoid errors.
* Make sure you look at the software code to identify the required return, the level of cash or the volatility cap as required by client specifications. The risk free (interest rate) is set to 2%.
* When specifying the required return, hike it **little by little** (it is set to .02) all the while checking the resulting CAGR, because it may break
* Remember that the "stock market" and the "capital market portfolio" are not EXACTLY the same entity.
* The "capital market portfolio" is a particular portfolio on the Markowitz efficient frontier
* of a particular selection of assets (your StockList)
* The "stock market" is your benchmark, the S&P500 or the DowJones index.
* The lookback is also a parameter you can try changing. For daily and weekly data, 60 is a good lookback.

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**DELIVERABLES:**

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**1. Benchmark. An excel spreadsheet with the monthly prices of the SPY (or DIA, select one), from** dt.datetime(2009, 1, 30), dt.datetime(2020, 1, 30)

Calculate in this spreadsheet (use Adjusted Close prices):

* CAGR
* # of years between the two dates
* Standard Deviation of the log returns of Adj Close Prices
* Average of the log returns of Adj Close Prices
* Sharpe Ratio (annualized)
* Standard Deviation of the log returns (annualized) = volatility

**2. Client A:**

* What program was used for Client A?
* CAGR of the portfolio returns
* Sharpe Ratio of the portfolio returns
* Standard Deviation of the portfolio returns (annualized) = volatility
* Were the client needs met by this program?
* How did this portfolio compare to the benchmark in (1)?

**3. Client B:**

* What program was used for Client B?
* CAGR of the portfolio returns
* Sharpe Ratio of the portfolio returns
* Standard Deviation of the portfolio returns (annualized) = volatility
* Were the client needs met by this program?
* How did this portfolio compare to the benchmark in (1)?

**4. Client C:**

* What program was used for Client C?
* CAGR of the portfolio returns
* Sharpe Ratio of the portfolio returns
* Standard Deviation of the portfolio returns (annualized) = volatility
* Were the client needs met by this program?
* How did this portfolio compare to the benchmark in (1)?

**5. Conclusion:**

* Compare the performance of Dow Jones stocks vs industry ETFs using the CLA algorithm and the Classic Markowitz.
* Which type of investment performs best in terms of CAGR and in terms of Sharpe Ratio, how does it compare to the benchmark in 1?

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