FinTech 545 Homework Week 05

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1. I created a Risk Management Library named RMLib. My directory looks like this

```
./
├── RMLib
│   ├── copula.py
│   ├── covar.py
│   ├── expected_shortfall.py
│   ├── fit_model.py
│   ├── non_psd.py
│   ├── returns.py
│   ├── simulation.py
│   └── value_at_risk.py
├── test.py
└── data
    └── all test inout csv files
```

Here are the function names:

1. Covariance & Correlation:
Cor
CorToCov
Cov
CovToCor
ewCorr
ewCovCor
ewCovar
ewVar

2. Non-PSD Fixes:
CorToCov
CovToCor
chol_psd
higham_nearestPSDCor
higham_nearestPSDCov
nearPSDCor
nearPSDCov
proj_spd

3. Simulation Methods:
simNormal
simPca

4. Return Calculation:
return_w_method

5. Parametric Models:
MLE_t
fit_general_t
fit_normal
fit_regression_t

6. VaR Calculation:
VaR_MLE_t
VaR_historic
VaR_norm_df
VaR_normal_distribution
VaR_simulation
VaR_t_df
VaR_t_distribution
Var_normal_distribution_EW

7. Expected Shortfall Calculation:
ES_historic
ES_norm_df
ES_normal_distribution
ES_normal_distribution_EW
ES_simulation
ES_t_df
ES_t_distribution

8. Copula:
aggRisk
copula_risk

The testing code `test.py` tests the functionality of my RM Library by taking input files, and compare my output against output files. My results are nearly identical to the output files, although I have to increase the tolerance for simulation questions.

Here is the console output for the testing.

```
testout_1.1    True
testout_1.2    True
testout_1.3    True
testout_1.4    True
testout_2.1    True
testout_2.2    True
testout_2.3    True          test6_1    True
testout_3.1    True          test6_2    True
testout_3.2    True          testout7_1    True
testout_3.3    True          testout7_2    True
testout_3.4    True          testout7_3    True
testout_4.1    True          testout8_1    True
testout_5.1    True          testout8_2    True
testout_5.2    True          testout8_3    True
testout_5.3    True          testout8_4    True
testout_5.4    True          testout8_5    True
testout_5.5    True          testout8_6    True
```

The output for 9-1 is close to the test result. Because of the nature of simulation, I cannot directly

compare that.Here is the result

```
    Stock            VaR95              ES95             VaR95_Pct  ES95_Pct
0     A          90.926824  114.99930096398587  0.0454634117865793    0.0575
1     B         111.053792   154.983021443826  0.03701793068047219  0.051661
2  Total  157.9970594204113  197.50845226074037             0.031599  0.039502
```

2. The VaR and ES result is:

```
Question 2:

VaR EW Normal w/ Lambda = 0.97
   VaR Absolute   VaR Diff from Mean
0      0.091169                 0.09029
VaR general T | MLE T
   VaR Absolute   VaR Diff from Mean
0      0.076476               0.076382
VaR Historic
   VaR Absolute   VaR Diff from Mean
0      0.078245               0.077278
ES EW Normal w/ Lambda = 0.97
   ES Absolute   ES Diff from Mean
0     0.114107              0.113227
ES general T | MLE T
   ES Absolute   ES Diff from Mean
0     0.113218              0.113124
ES Historic
   ES Absolute   ES Diff from Mean
0     0.112664              0.111968
```

The VaR under exponentially weighted normal is greater than both VaR fitted by MLE T distribution and historical VaR, which suggests that the recent returns are more volatile than past data, because EW puts a higher weight on recent data. The expected shortfall for these 3 models are very close to each other.

The absolute VaR/ES is very close to the VaR/ES difference from mean. This implies that the average return is close to zero.

3. The 95% value at risk and expected shortfall under Copula is:

```
Portfolio A:
    Stock              VaR95                 ES95 VaR95_Pct  ES95_Pct
35  Total  8340.049895614682  10448.56663757482  0.027805  0.034834

Portfolio B:
    Stock              VaR95                 ES95 VaR95_Pct  ES95_Pct
32  Total  6818.447134423607  8552.413868649955  0.023162  0.029052

Portfolio C:
    Stock              VaR95                 ES95 VaR95_Pct  ES95_Pct
32  Total  5754.165059662527  7233.337351563172  0.021308  0.026786

Total:
    Stock              VaR95                 ES95 VaR95_Pct  ES95_Pct
99  Total  22150.18831328848  27793.5175065322  0.025626  0.032154
```

Compared to last week's functions using the same dataset (and I also changed EW covariance to covariance to match the process of this week's copula):

```
Arithmetic Return:
For Portfolio A, the 95% VaR is: $7946.138
For Portfolio B, the 95% VaR is: $6674.0675
For Portfolio C, the 95% VaR is: $5635.3731
For Portfolio Total, the 95% VaR is: $19978.9998
```

We can see that the portfolio C's VaRs are very similar, because both model are built upon normal assumption for portfolio C. Last week's VaR of A and B are smaller than copula derived VaR, which could be explained by different model assumption.