Stock Analysis of Under Armour, Amazon, Baidu & Nike

EXTREME VALUE THEORY & COPULA-BASED RISK MEASURES

Rehareha RAMANANA | M5MF10 Quantitative Risk Management | December 14th 2018

PREFACE

The language that I used and the results that will be exposed in this report, are from a notebook available on my GitHub: https://github.com/big21ray/QRM. I think it's important to say that the notebook was only a way for me to compute results, but is not clean in itself and also, it's also for a matter of transparency. I rarely commented and some of the cases are useless. I tried doing it in Python, and for matter of diversification but also because it's easier, I decided to do the whole project in R. I decided to do the assignment by myself, first because my attendance rate is not very high meaning that I did not ask anyone to do it with me, and because from my previous experience, teamwork is important, but I also prefer reasoning and doing the entirety of the project to seize all the meaning behind it.

In Python, I decided to use the following packages: Numpy, Pandas, Arch, Scipy, Seaborne, Matplotlib, Tabulate and Statsmodel.

And in R, I decided to use : rugarch, qrm, dplyr and evir.

PART A : EXTREME-VALUE THEORY

This time around, we work with the stock indices of Amazon, Nike, Baidu & Under Armour extracted from the NYSE. First thing first, we are going to help Pietro measures the risk of his investment, and we compute the daily log returns and the log losses of the Under Armour stock values of the period : 2010-12-21 and 2018-11-30. Here is a first idea of the values.

	Date	UAA	Losses
0	2010-12-21	7.4129	NaN
1	2010-12-22	7.0371	0.052026
2	2010-12-23	7.0835	-0.006572
3	2010-12-27	7.0383	0.006401
4	2010-12-28	6.9053	0.019077
5	2010-12-29	7.0513	-0.020923
6	2010-12-30	7.1210	-0.009836
7	2010-12-31	7.0823	0.005449
8	2011-01-03	7.1765	-0.013213
9	2011-01-04	7.0577	0.016693
10	2011-01-05	7.1727	-0.016163
11	2011-01-06	7.0564	0.016347
12	2011-01-07	6.9157	0.020141
13	2011-01-10	7.1313	-0.030699

Fig 1: First 13 values available in our dataset with losses being the daily linearized losses

To have an idea of what the log losses look like for the period of time here is the graph of the evolution of the daily closing price.

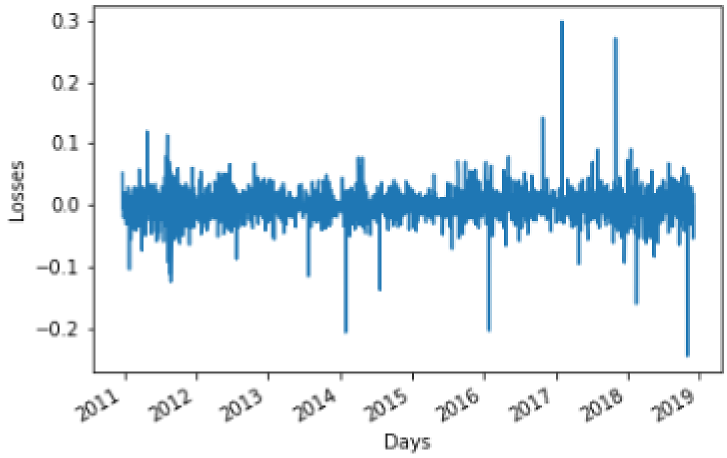

Fig 2: Evolution of the price of UAA from 2012 to 2018

(i) *Fit a standard GARCH(1,1) model, with constant conditional mean, and standard normal errors, to the loss data using the entire sample. Extract the standardized residuals Z1,....,ZN.*

I fitted a GARCH(1,1) model to the log-losses just like the precedent project. Here are the first 15 values in the columns 'Standardized Residuals' ;

	Date	UAA	Losses	Standardized Residuals
1	2010-12-22	7.0371	0.052026	-0.222941
2	2010-12-23	7.0835	-0.006572	0.270290
3	2010-12-27	7.0383	0.006401	0.762663
4	2010-12-28	6.9053	0.019077	-0.782468
5	2010-12-29	7.0513	-0.020923	-0.354044
6	2010-12-30	7.1210	-0.009836	0.237746
7	2010-12-31	7.0823	0.005449	-0.491045
8	2011-01-03	7.1765	-0.013213	0.680800
9	2011-01-04	7.0577	0.016693	-0.606799
10	2011-01-05	7.1727	-0.016163	0.666222
11	2011-01-06	7.0564	0.016347	0.813937
12	2011-01-07	6.9157	0.020141	-1.170084
13	2011-01-10	7.1313	-0.030699	0.607574
14	2011-01-11	7.0241	0.015146	-0.418981
15	2011-01-12	7.1055	-0.011522	-0.290439

Fig 3 : First 15 values of the table with the Standardized Residuals

(ii) Plot the sample mean excess function en, corresponding to Z1, .., Zn.

Here is the graph asked in the question.

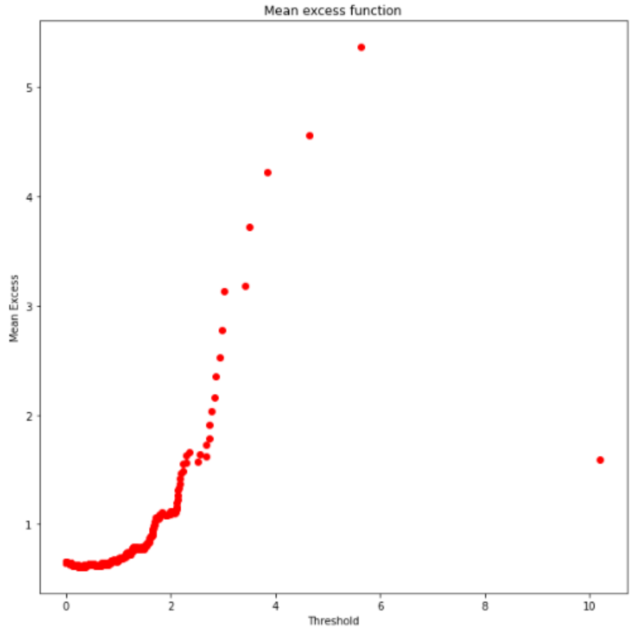

Fig 4 : Plot of the Mean Excess Function for positive Standardized Residuals

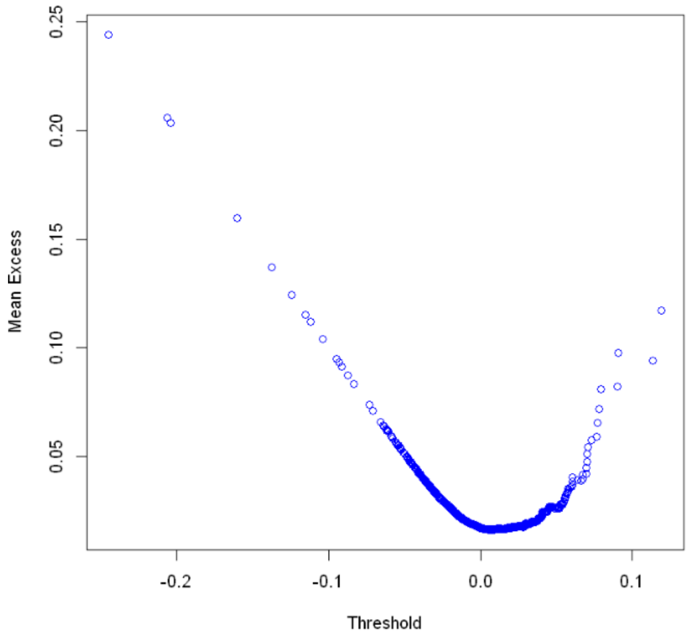

Fig 5 : Plot of the Mean excess function for all the values of the Standardized Residuals *(iii) Fit a generalized pareto distribution (GPD) to the standardized residuals exceeding a threshold u > 0 , which you should select based on the plot of the sample mean excess function.*

I decided to plot the fitted distribution and the empirical quantiles using in R : 'plotFittedGPDvsEmpiricalExcesses'. We see that we have a graph very similar to the graph we found when we working on the Danish Fire insurance, so the assumption of u close to 1 seems to be a good decision.

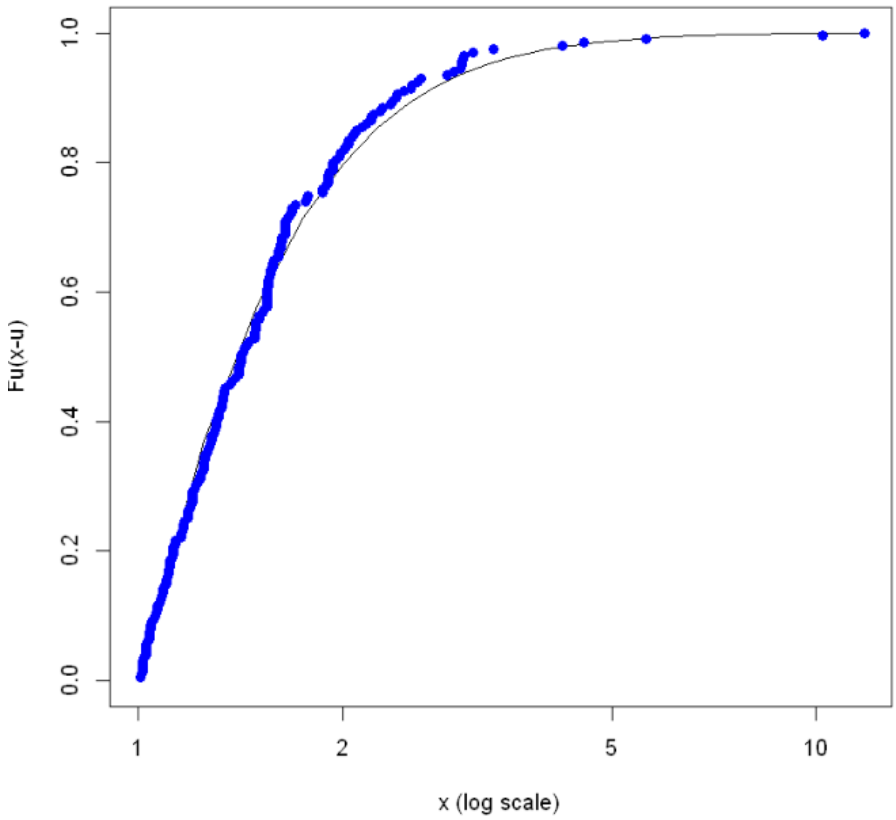

Fig 6 : Fitted GPD vs Empirical Excesses

(iv) Using a volatility forecast from the estimated GARCH model and the fitted GPD, compute day-ahead VaR and ES forecasts at 95% and 99% confidence levels for the next trading day.

So for this question, I am not entirely confident of the results, so at least, I would like to explain my thought process. First thing I did was fit a GARCH model on losses of the UAA prices.

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(0,0,0)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu     -0.000773    0.000591   -1.3091  0.19051
omega   0.000002    0.000000   12.6367  0.00000
alpha1  0.002455    0.000111   22.0388  0.00000
beta1   0.994260    0.000154 6474.9255  0.00000

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu     -0.000773    0.000537   -1.4410 0.149577
omega   0.000002    0.000000    5.4517 0.000000
alpha1  0.002455    0.001118    2.1961 0.028088
beta1   0.994260    0.000136 7302.0701 0.000000

LogLikelihood : 4425.105

Information Criteria
------------------------------------

Akaike       -4.4211
Bayes        -4.4099
Shibata      -4.4211
Hannan-Quinn -4.4170
```

Fig 7 : Summary of the GARCH Fitting of the daily linearized losses of UAA

From this, I fitted a Generalized Pareto Distribution to the Standardized Residuals with threshold equal to 1 from the GARCH Model. Here is the summary of this fitting.

$threshold
1
$p.less.thresh
0.9005
$n.exceed
199
$type
'ml'
$par.ests

xi	0.241163753655955
beta	0.512996279702445

$par.ses

xi	0.0757034491367197
beta	0.0524761452313579

$varcov

0.005731012	-0.002168317
-0.002168317	0.002753746

$information
'observed'
$converged
TRUE
$ll.max
-114.157369903598

Fig 8 : Summary of the GPD fitting on Standardized Residuals

I then computed the cdf with pgpd in R with the parameters that I computed before, and calculated the value in u = 1. From that I calculated the quantiles values from the formula in Part 4, Slide 61. And from that I computed the ES. I then used the formula in Part 4, Slide 62, with μ and σ being the values from the GARCH fitting model forecast with horizon equal to 1.

Here are my results:

	VaR	ES
Confidence level = 95%	0.0545	0.1391
Confidence level = 99%	0.0966	0.0835

PART B : Copula-based risk measures using Monte-Carlo

(i) *First, for each stock, fit a univariate GARCH(1,1) model, with constant conditional mean and standard normal errors, to daily log returns and extract the standardized residuals. Report your estimates and their standard errors.*

Here are the values of the estimate and the standard errors.

AMAZON	Parameters Values	Standard Errors
μ	0.16444	0.0390
Ω	0.50465	0.0979
σ_1	0.16373	0.0256
β_1	0.72701	0.0360

BIDU	Parameters Values	Standard Errors
μ	0.0341	0.0495
Ω	0.0430	0.0077
σ_1	0.0180	0.0019
β_1	0.9747	0.0017
NIKE	Parameters Values	Standard Errors

μ	0.0871	0.0324
Ω	0.8814	0.2164
σ_1	0.1050	0.0287
β_1	0.5026	0.1114

UAA	Parameters Values	Standard Errors
μ	0.0741	0.0560
Ω	0.0254	0.0041
σ_1	0.0025	0.0006
β_1	0.9940	0.0001

(ii) *Assess whether the standardized residuals computed in (i) are consistent with the iid assumption by studying their cross-correlogram and the cross-correlogram of their absolute values.*

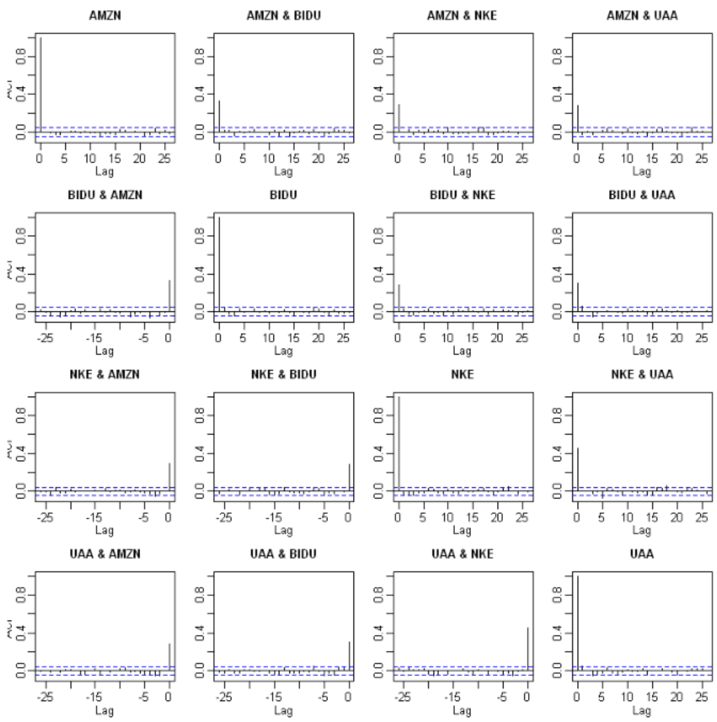

Fig 9 : Cross-correlogram of the standardized residuals

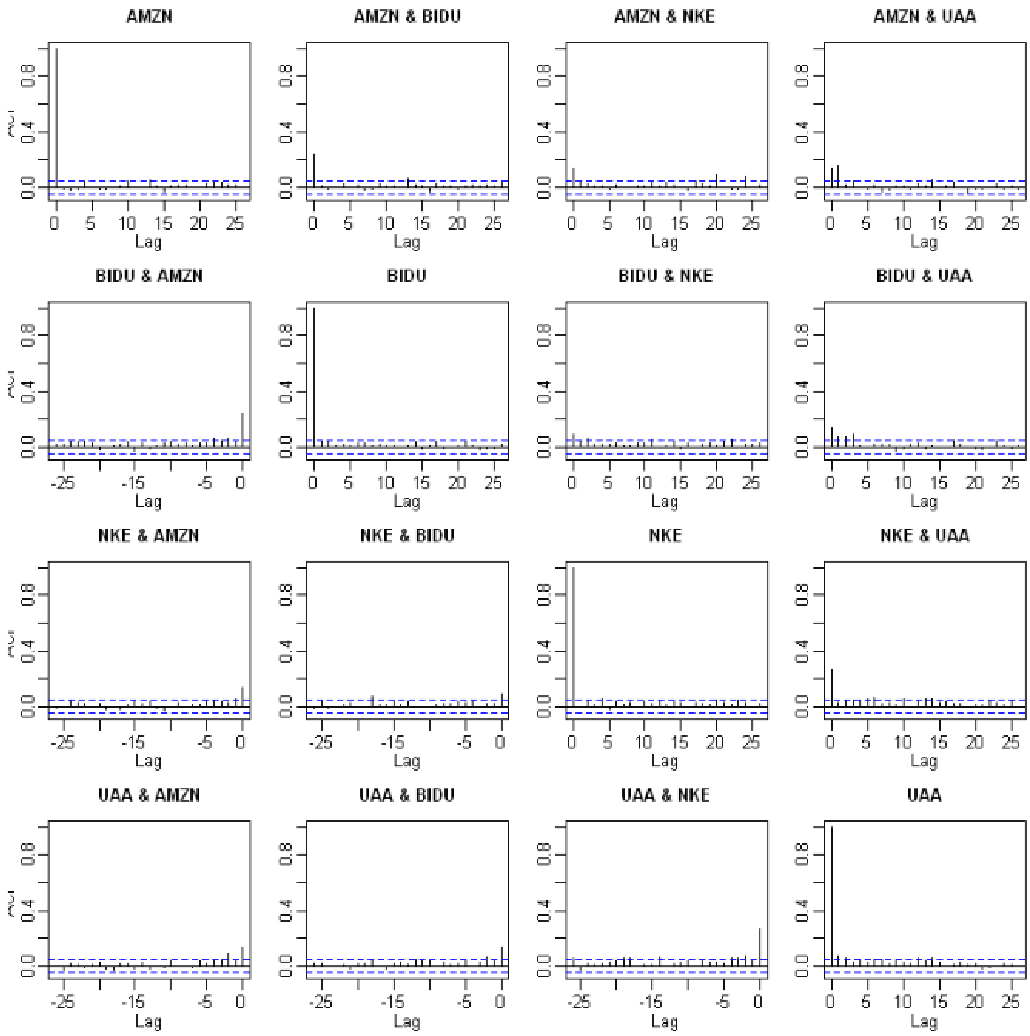

Fig 10 : Cross-correlogram of the absolute values of the standardized residuals

Conclusions :

- The iid assumption seems to be consistent. There is no clear evidence of non-independence, a part from some contemporaneous correlations.

(iii) *Fit a (four dimensional) Gauss copula $G^{Ga}{}_{p}$ to the standardized residuals using the method of moments. Report the estimated matrix P.*

Here is the estimated matrix P, that is given after using the 'fit.gausscopula' method in R.

	AMZN	BIDU	NKE	UAA
AMZN	1.0	0.4324	0.3872	0.3453
BIDU	0.4324	1.0	0.3412	0.3511
NKE	0.3872	0.3412	1.0	0.5476
UAA	0.3453	0.3511	0.5476	1.0

(iv) *Compute VaR and ES at 95% and 99% confidence levels through Monte Carlo simulations.*

For this question, I simulated N = 100000 values through the fitted Copula Gauss from the question before with the method 'rcopula.gauss'. I used the correlation matrix used in the precedent question. After creating this matrix, I calculated the matrix of returns as the formula proposed and using the 'quantile' function in R to compute the quantile function from the empirical distribution available through the standardized residuals computed before. I then just applied the formulas. Here are the results:

	VaR	ES
Confidence level 95%	2.566	3.656
Confidence level 99%	4.278	5.582