GARCH Analysis

CUNY SPS MSDS

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In this analysis, we will build a GARCH for one of the assets in our investment portfolio. We then use the model to predict the return and volatility for the next 10 days.

Our investment portfolio includes the following assets. In this analysis, we will focus on the equity assets.

Ticker	Type	Sector	Units	Amount
US30Y	U.S. 30 Year Treasury	NaN	467317.00	42262981.19
HSON	Common Stock	COMMERCIAL SERVICES	36138.24	1263031.49
GOGO	Common Stock	COMMUNICATIONS	94822.19	1263031.57
JAKK	Common Stock	CONSUMER DURABLES	54044.99	1263031.42
CALM	Common Stock	CONSUMER NON-DURABLES	22216.91	1263031.33
HRB	Common Stock	CONSUMER SERVICES	28111.09	1263031.27
HDSN	Common Stock	DISTRIBUTION SERVICES	159071.98	1263031.52
BELFA	Common Stock	ELECTRONIC TECHNOLOGY	44285.81	1263031.30
ARLP	Common Stock	ENERGY MINERALS	52890.76	1263031.35
CI	Common Stock	HEALTH SERVICES	4350.03	1263031.21
SRTS	Common Stock	HEALTH TECHNOLOGY	85339.97	1263031.56
LNG	Common Stock	INDUSTRIAL SERVICES	7551.75	1263030.19
BSM	Common Stock	MISCELLANEOUS	80447.87	1263031.56
HUDI	Common Stock	NON-ENERGY MINERALS	42612.40	1263031.54
CF	Common Stock	PROCESS INDUSTRIES	12810.95	1263031.56
CSL	Common Stock	PRODUCER MANUFACTURING	4335.84	1263030.19
MUSA	Common Stock	RETAIL TRADE	4561.65	1263029.65
AZPN	Common Stock	TECHNOLOGY SERVICES	5579.50	1263031.42
ASC	Common Stock	TRANSPORTATION	126303.15	1263031.50
ED	Common Stock	UTILITIES	12966.13	1263030.72
YCS	ETF	NaN	25261.96	1599839.93
UUP	ETF	NaN	54416.32	1599839.81
EUO	ETF	NaN	47870.73	1599839.80

Ticker	Type	Sector	Units	Amount
EWV	ETF	NaN	79832.33	1599839.89
DIG	ETF	NaN	44390.67	1599839.75
TTT	ETF	NaN	23645.28	1599839.64
ERX	ETF	NaN	29349.47	1599839.61
TMV	ETF	NaN	13430.49	1599839.97
TBT	ETF	NaN	54509.02	1599839.74
TYO	ETF	NaN	127782.74	1599839.90

We will demonstrate the GARCH process using one of our assets, 'HSON', as an example. We use the *rugarch* package in R to construct our model. It is a powerful tool for building GARCH models with supportive output summaries.

First, let's build a model with ar = 5, ma = 5, alpha = 5, beta = 5. The following are the estimated parameters.

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.002282	0.001975	1.155528	0.247874
ar1	-0.390539	0.276836	-1.410719	0.158327
ar2	0.299202	0.239189	1.250903	0.210970
ar3	-0.307978	0.343824	-0.895743	0.370390
ar4	0.257204	0.111308	2.310752	0.020847
ar5	0.527938	0.174548	3.024611	0.002490
ma1	0.323521	0.287829	1.124006	0.261010
ma2	-0.362023	0.250290	-1.446413	0.148061
ma3	0.243253	0.382543	0.635883	0.524853
ma4	-0.245103	0.119780	-2.046284	0.040728
ma5	-0.394276	0.206220	-1.911918	0.055887
omega	0.000000	0.000017	0.000000	1.000000
alpha1	0.164288	0.048520	3.386009	0.000709
alpha2	0.000025	0.067529	0.000373	0.999703
alpha3	0.000018	0.070694	0.000250	0.999800

The P-values of the Optimal Parameters indicate that some of the parameters are statistically insignificant. We will use Backward Elimination to reduce the model complexity by removing the last term of each parameter with P-value greater than 0.05.

The Parameters of our final model are ar = 4, ma = 1, alpha = 1, beta = 3. The following are the estimated parameters.

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.00175	0.00081	2.16057	0.03073
ar1	0.92580	0.05038	18.37713	0.00000
ar2	0.05210	0.06993	0.74508	0.45622
ar3	-0.11876	0.08412	-1.41183	0.15800
ar4	0.11840	0.05754	2.05765	0.03962
ma1	-1.00000	0.00049	-2046.17665	0.00000

omega	0.00000	0.00002	0.00000	1.00000
alpha1	0.19490	0.06213	3.13683	0.00171
beta1	0.09747	0.05463	1.78425	0.07438
beta2	0.00000	0.15547	0.00000	1.00000
beta3	0.69636	0.03324	20.94814	0.00000

The P-values of the last alpha and beta terms are less than 0.01, which indicates that our time series exhibits heteroskedasticity.

The followings are the results of the Weighted Ljung-Box Tests and the Adjusted Pearson Goodness-of-Fit Test:

Weighted Ljung-Box Test on Standardized Residuals

	statistic	p-value
Lag[1]	0.03059	0.86120
Lag[2*(p+q)+(p+q)-1][14]	5.27336	1.00000
Lag[4*(p+q)+(p+q)-1][24]	13.53741	0.32580

d.o.f=5

Weighted Ljung-Box Test on Standardized Squared Residuals

	statistic	p-value
Lag[1]	0.01741	0.89500
Lag[2*(p+q)+(p+q)-1][11]	4.69891	0.62660
Lag[4*(p+q)+(p+q)-1][19]	7.25944	0.75650

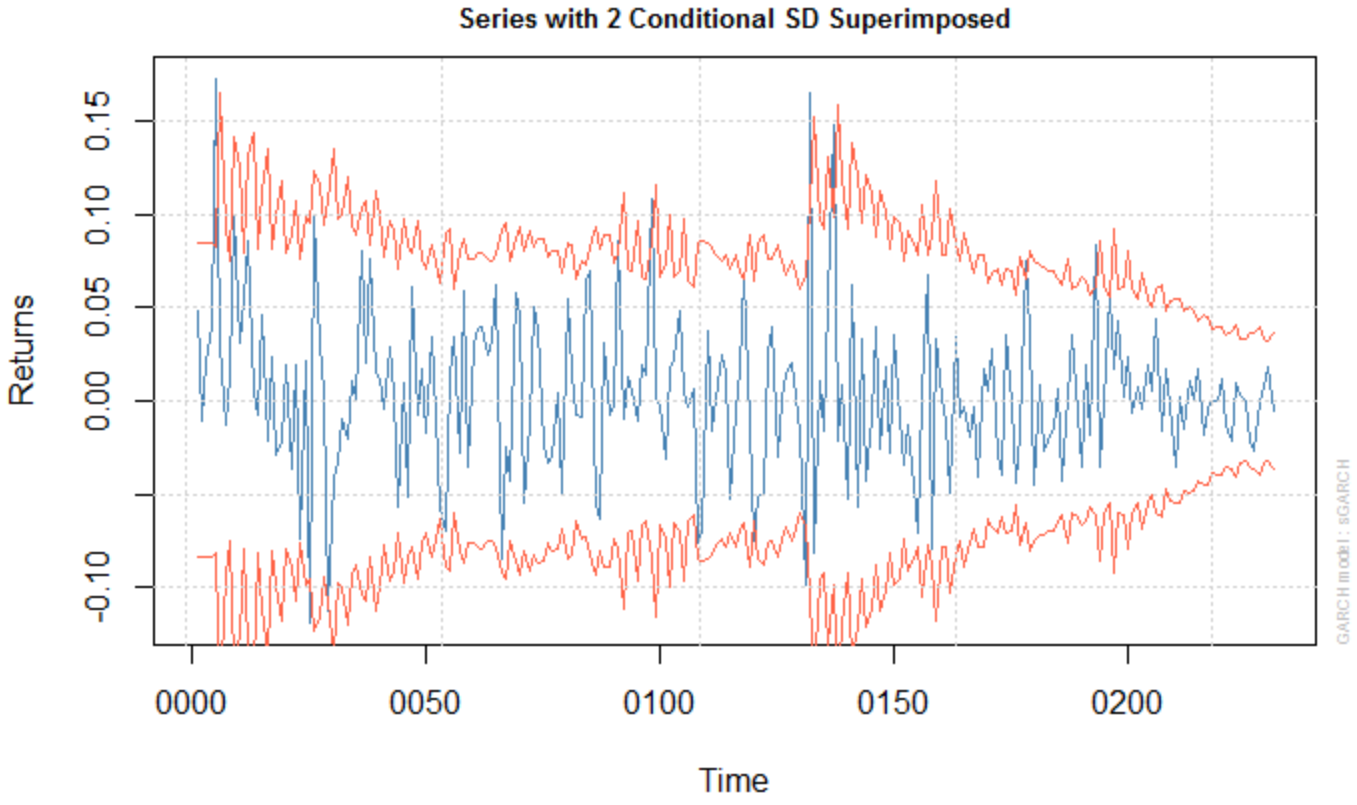
d.o.f=4

Adjusted Pearson Goodness-of-Fit Test:

group	statistic	p-value(g-1)
20	23.81	0.2037
30	30.43	0.3928
40	42.42	0.3258
50	48.00	0.5135

The Weighted Ljung-Box Tests and the Adjusted Pearson Goodness-of-Fit Test all fail to reject that the residuals are dependent, which implies that our model is valid.

The following plot shows the returns and the modeled volatility. We confirm that there is heteroskedasticity in the time series.



Since the volatility is not constant, our previous risk assessment of calculating the VaR using constant volatility may not be reliable. Calculating the potential loss using the estimated volatility from a GARCH model would a more appropriate method.

Finally, let's predict the returns and standard deviation for the next 10 days.

	Series	Sigma
T+1	0.0024769	0.01518
T+2	0.0007862	0.01560
T+3	0.0036509	0.01731
T+4	0.0025338	0.01575
T+5	0.0027751	0.01555
T+6	0.0023999	0.01671
T+7	0.0025370	0.01595
T+8	0.0024835	0.01558
T+9	0.0025141	0.01630
T+10	0.0024791	0.01596