AL//MRM/17 31.05.2020

"Market Risk Model Validation –Amid Covid 19 Crises

Extract

The global COVID-19 pandemic has accentuated Global Financial crises.There has been significant change in Market conditions and Structure, with spikes in Volatility across asset classes.

In this research paper, we attempt to test the efficacy of Market Risk Models measuring VaR and conditional VaR (ES) .

We have taken the MSFT (Microsft) stock prices from 2018 till May'2020 and computed its daily return(Log Scale).

The Daily VaR (99% CF. Level) under 1. Gaussian Method, 2. Historical Simulation, 3. Modified Approach, was computed.

The rolling 1 day VaR was estimated and compared with actual MSFT returns.

The Number of Violations along with Violations Matrix and Kupiec Unconditional Coverage test was conducted for all the 3 methods.

The results are **intriguing**. The test statistics and associated p-values are mentioned.

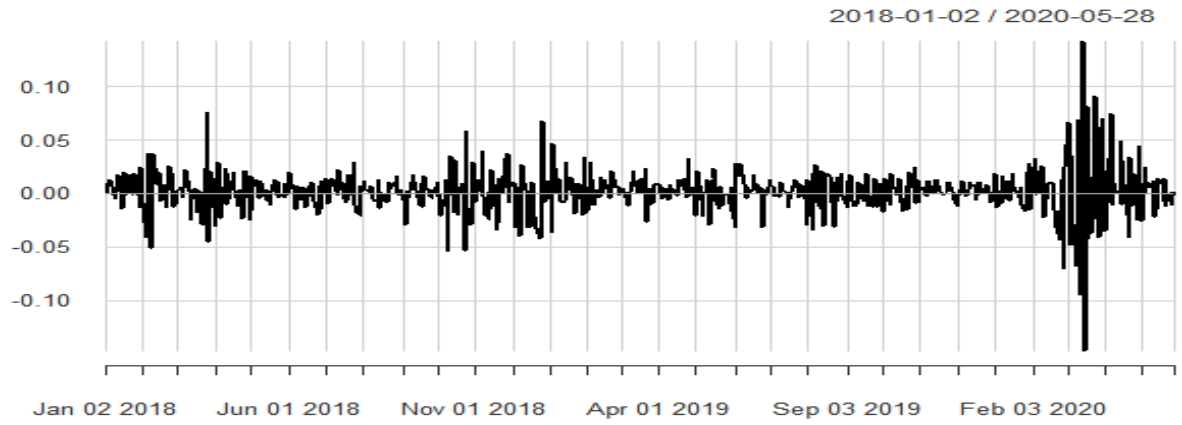
In order to internally validate the Market risk Models, Firms must not rely solely on readymade "quant" libraries, rather they should develop the Risk Libraries with support from experts.

Volatility estimates under GARCH (p,q) and State- Space (SV- Stochastic Volatility Model) seem to capture time varying property well. In particular SV model seems to be the best predictor of volatility .

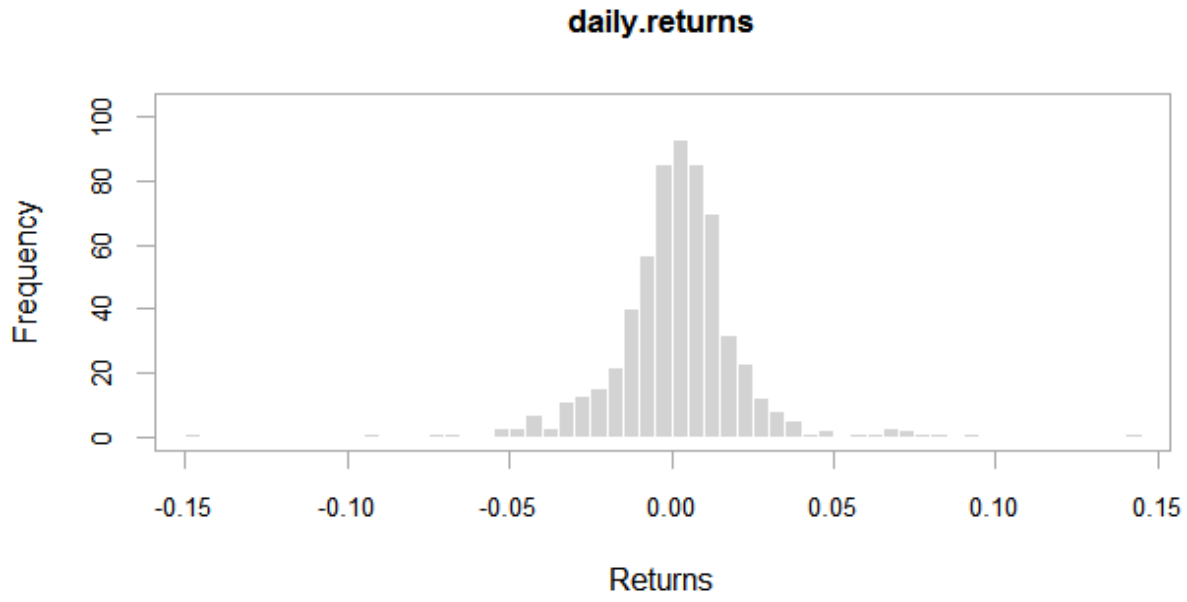
The results from the two models are enclosed.

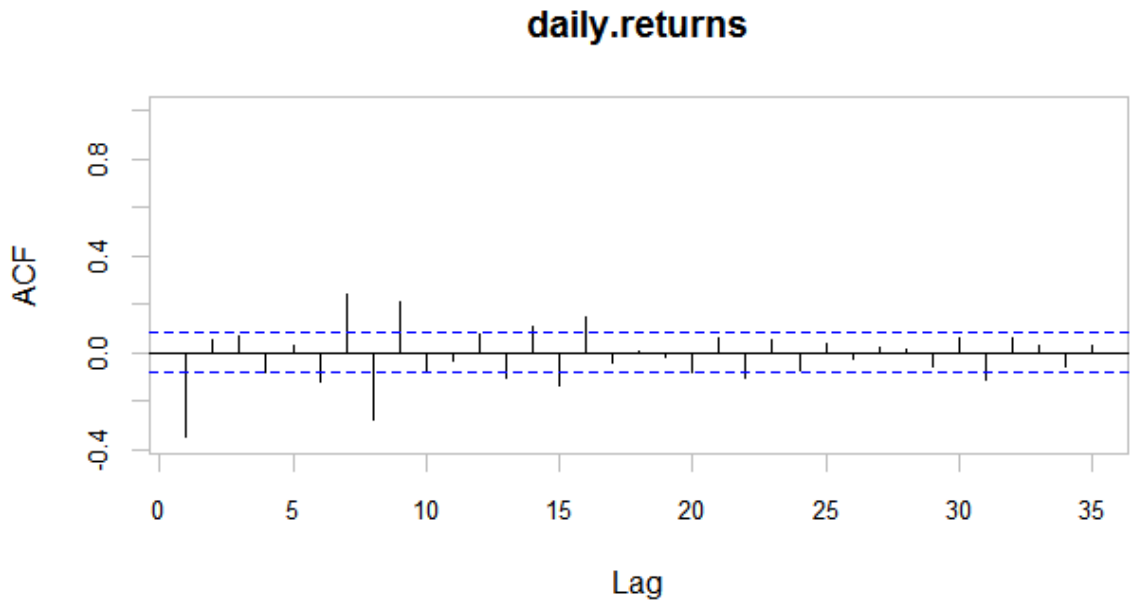
MSFT Daily returns Analyses:

```
 MSFTRET    Daily Returns(Log)

2018-01-02  0.0000000000
2018-01-03  0.0046538004
2018-01-04  0.0088015019
2018-01-05  0.0123981974
2018-01-08  0.0010203411
2018-01-09 -0.0006794752

:
:
2020-01-30  2.820766e-02
2020-01-31 -1.475868e-02
2020-02-03  2.437885e-02
2020-02-04  3.291662e-02
2020-02-05 -1.221434e-03
```




```
daily.returns (Statistical summary)
 Min.      :   -0.147390
 1st Qu.   :   -0.007209
 Median    :    0.001828
 Mean      :    0.001509
 3rd Qu.   :    0.010742
 Max.      :    0.142169
 Std_dev   :    0.0206
 Coefvar   :    13.65176
 Skewness  :    0.030075
 Kurtosis  :    10.23013
```



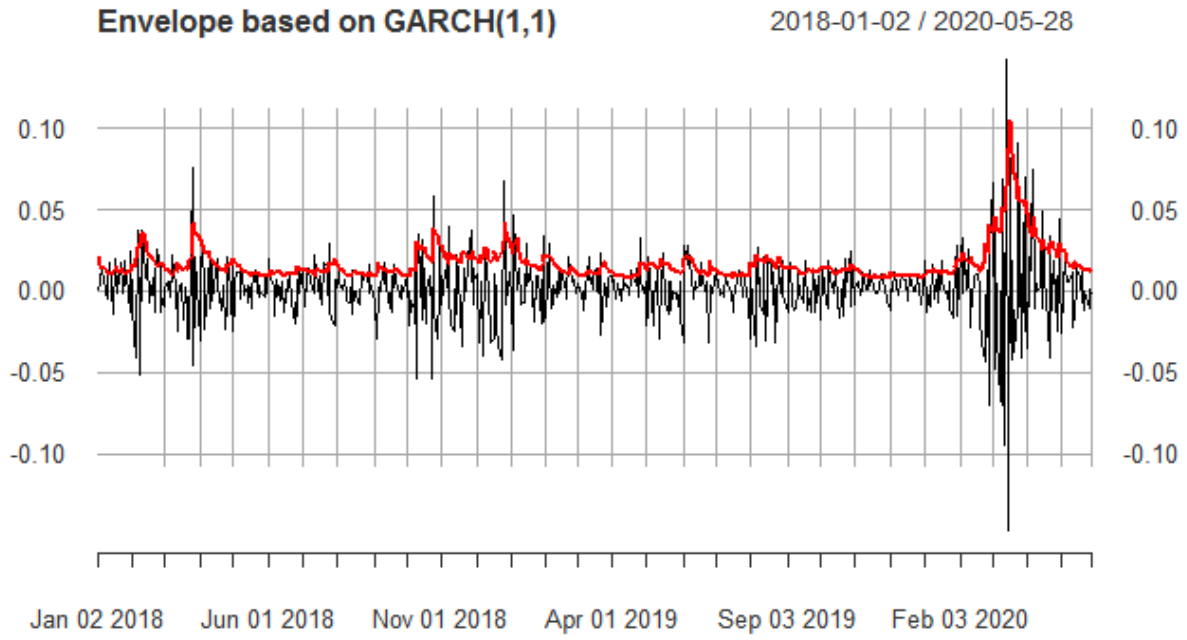


Volatility Modelling:

Title: GARCH Modelling

```
Coefficient(s):
        mu             omega            alpha1            beta1
       1.9914e-03     1.5486e-05     2.4418e-01     7.1860e-01

Std. Errors:
 based on Hessian
```

```
Error Analysis:
        Estimate  Std. Error  t value Pr(>|t|)
mu     1.991e-03   5.032e-04    3.957 7.59e-05 ***
omega  1.549e-05   4.582e-06    3.380 0.000725 ***
alpha1 2.442e-01   4.311e-02    5.663 1.48e-08 ***
beta1  7.186e-01   4.076e-02   17.628  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log Likelihood:
 1668.201    normalized:  2.757357

Description:
 Fri May 29 15:11:36 2020 by user: Manas Pandey


Standardised Residuals Tests:
                                Statistic p-Value
 Jarque-Bera Test   R    Chi^2  33.47656  5.378458e-08
 Shapiro-Wilk Test  R    W      0.9888699 0.0001486056
 Ljung-Box Test     R    Q(10)  22.24491  0.01390442
 Ljung-Box Test     R    Q(15)  24.72077  0.05382135
 Ljung-Box Test     R    Q(20)  31.29137  0.05145951
 Ljung-Box Test     R^2  Q(10)  19.56154  0.03368339
 Ljung-Box Test     R^2  Q(15)  25.58955  0.04256471
 Ljung-Box Test     R^2  Q(20)  28.15404  0.1058028
 LM Arch Test       R    TR^2   20.41299  0.05966592

Information Criterion Statistics:
      AIC       BIC       SIC      HQIC
-5.501491 -5.472365 -5.501577 -5.490157
```



GARCH (p,q) Volatility Forecast(10 Days ahead)

Point	Forecast	Lo 80	Hi 80	Lo 95	Hi 95
606	0.01154605	0.009058300	0.01403380	0.0077413647	0.01535074
607	0.01154605	0.008054865	0.01503724	0.0062067427	0.01688536
608	0.01154605	0.007262626	0.01582948	0.0049951174	0.01809698
609	0.01154605	0.006579038	0.01651306	0.0039496599	0.01914244
610	0.01154605	0.005963648	0.01712845	0.0030085032	0.02008360
611	0.01154605	0.005395586	0.01769652	0.0021397271	0.02095237
612	0.01154605	0.004862427	0.01822967	0.0013243309	0.02176777
613	0.01154605	0.004356073	0.01873603	0.0005499295	0.02254217
614	0.01154605	0.003870901	0.01922120	-0.0001920782	0.02328418
615	0.01154605	0.003402816	0.01968929	-0.0009079521	0.02400005

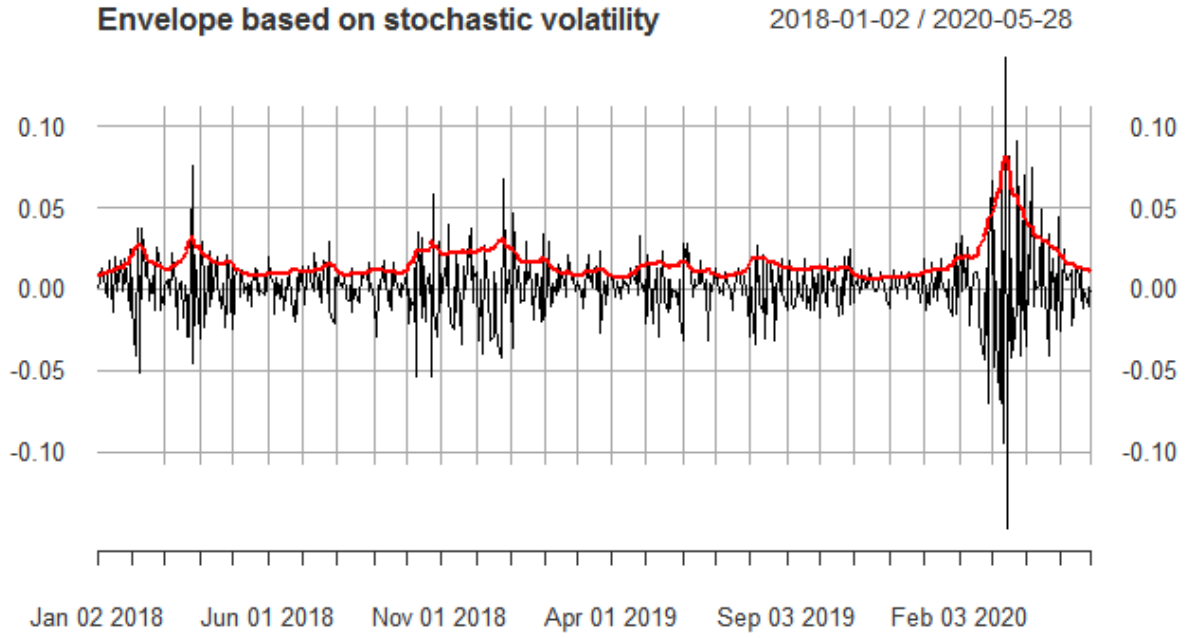
Volatility Modelling

Title: Stochastic Volatility Model

Summary of 5000 MCMC draws after a burn-in of 1000.

Posterior draws of parameters (thinning = 1):

	mean	sd
mu	-8.610	0.478
phi	0.955	0.018
sigma	0.339	0.051
nu	73.336	15.208
exp(mu/2)	0.014	0.014
sigma^2	0.117	0.035



SV Volatility Forecast(10 Days ahead)

Point	Forecast	Lo 80	Hi 80	Lo 95	Hi 95
606	0.010773085	0.010308062	0.01123811	0.0100618942	0.01148428
607	0.010569129	0.009607169	0.01153109	0.0090979381	0.01204032
608	0.010369253	0.008825230	0.01191328	0.0080078738	0.01273063
609	0.010173374	0.007976585	0.01237016	0.0068136748	0.01353307
610	0.009981412	0.007071910	0.01289091	0.0055317131	0.01443111

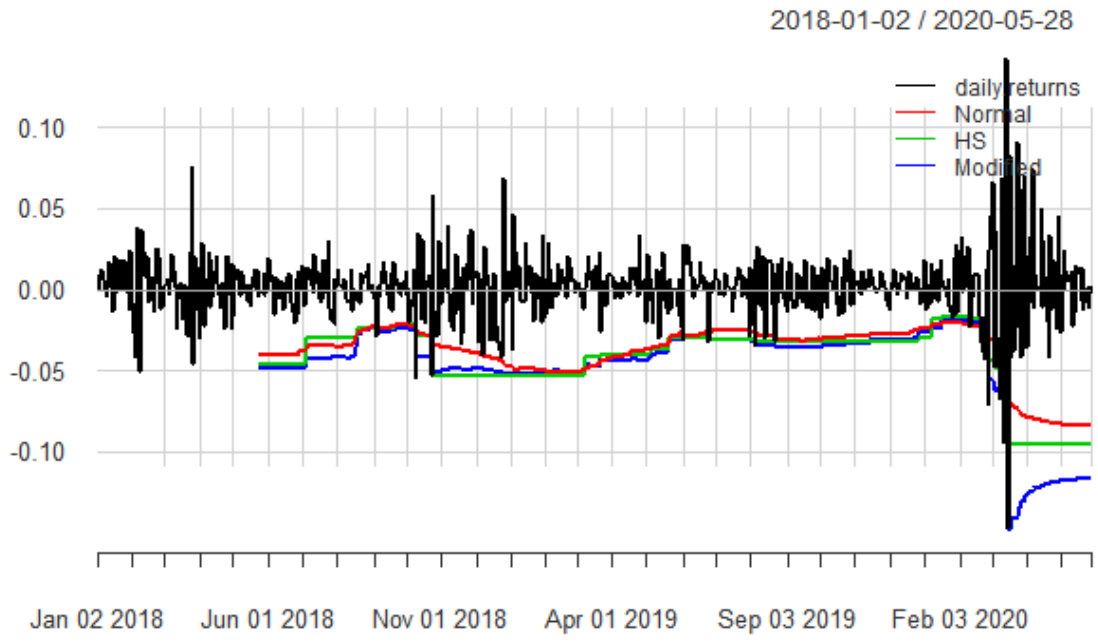
VaR (Value at Risk Computation): 99%, 1D VaR

MSVAR(Daily Return)	Historical	Gaussian	Modified
VaR(0.99, 1D)	-0.05116267	-0.04633695	-0.09517763
ES	-0.07708578	-0.05330854	-0.09517763

VaR.Estimations (Rolling 1 day)

	Normal	HS	Modified
2018-05-25	-0.04023478	-0.04601243	-0.04908209
2018-05-29	-0.04022881	-0.04601243	-0.04908989
2018-05-30	-0.04032169	-0.04601243	-0.04896976
2018-05-31	-0.04032163	-0.04601243	-0.04897101
2018-06-01	-0.04038357	-0.04601243	-0.04887129
2018-06-04	-0.04041137	-0.04601243	-0.04883733
2018-06-05	-0.04034637	-0.04601243	-0.04893545
2018-06-06	-0.04023209	-0.04601243	-0.04907593
2018-06-07	-0.04023230	-0.04601243	-0.04907562
2018-06-08	-0.04059721	-0.04601243	-0.04883091

:
:

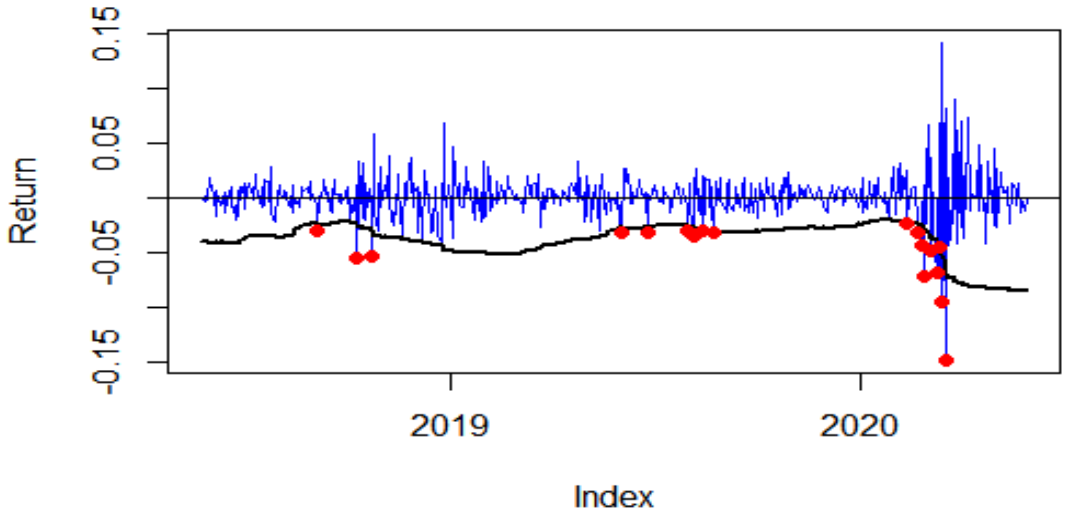


:

Violation.dates

```
 [1] "2018-09-05" "2018-10-10" "2018-10-24" "2019-06-03" "2019-06-25"
"2019-07-31" "2019-08-05"
 [8] "2019-08-14" "2019-08-23" "2020-02-11" "2020-02-21" "2020-02-24"
"2020-02-27" "2020-03-03"
[15] "2020-03-09" "2020-03-11" "2020-03-12" "2020-03-16",......
```

Violations plot



Violations.matrix

	Exp.	Act.	1-alpha	Percent	Vio. Ratio
Normal	5.05	18	0.01	0.03564356	3.564356
HS	5.05	16	0.01	0.03168317	3.168317
Modified	5.05	13	0.01	0.02574257	2.574257

Backtest Value at Risk (VaR)

- `LRuc` The unconditional coverage test of Kupiec

BackTest Results

```
        LRuc (N) :      19.893
        p value  :      8.189965e-06

        LRuc (HS):      15.19979
        p value  :      9.675464e-05

        LRuc (M) :      8.779676
        p value  :      0.00304618
```

Conclusion:

This empirical study has confirmed that traditional VaR models are likely to fail in estimating VaR and conditional VaR numbers.It would be tough to convince the regulators on the robustness and precision of Market Risk Models.

The way forward is to use advanced Volatility Models like SV models, which can capture the time varying effect through state realisations.

The Research Team,
ALBEDO ENERGY
##

TABLE 3-A2: Model validation process scorecard.

Validation process	**Score**			
	1: No evidence	**2: Due consideration lacking**	**3: Some consideration**	**4: Fully evident**
Paradigm				
To what extent was the conceptual soundness of paradigm checked?				
To what extent was the review performed by suitably skilled experts?				
Methods/theory				
To what extent is the underlying model theory consistent with published research and sound industry practice?				
To what extent were research publications considered of appropriate quality/standing?				
To what extent was the methodology benchmarked against appropriate industry practice?				
To what extent are approximations made within agreed tolerance levels?				
Design				
To what extent was it ascertained that assumptions are clearly formulated?				
To what extent was the appropriateness and the completeness of assumptions checked?				
To what extent was it checked that all variables employed have been clearly defined and listed?				
To what extent have the causal relationships between variables been noted?				
To what extent have *input* data been assessed in terms of reasonableness, validity and understanding?				
To what extent has it been ascertained that *outputs* are clearly defined?				
To what extent has the design been evaluated in terms of over-complexity/over-simplification?				
To what extent has the model builder benchmarked the design against existing best practice models?				
To what extent was the design independently benchmarked against existing best practice models?				
To what extent have special cases been dealt with appropriately? (e.g. terminal conditions or products with path-dependent pay-off)				
Data/variables				
To what extent have input data been checked to gauge reliability/suitability/validity/completeness?				
To what extent has it been checked that data involving subjective assessment of expert opinion been appropriately incorporated?				
To what extent was the procedure for the collation of expert opinion scrutinised?				
To what extent has expert opinion been validated in terms of logical considerations?				
To what extent has the expert selection process been assessed as sound?				
To what extent was it verified that data are representative of relevant (general and stressed) market conditions?				
To what extent was it verified that data are representative of the company's portfolio?				
To what extent have inadequate or missing data been re-assessed and reviewed for model feasibility?				
Algorithms/code				
To what extent was the algorithms/code checked against the model formulation and underlying theory?				
To what extent were key assumptions and variables analysed with respect to their impact on model outputs?				
To what extent was an independent construction of an identical model undertaken?				
To what extent was the code rigorously tested against a benchmark model?				
To what extent was technical proofreading of the code performed?				
Outputs				
To what extent was model output benchmarked against best practice models (e.g. against a vendor model using the same input data set)?				
To what extent was the reasonableness and validity of model outputs assessed?				
To what extent has a comparison of model outputs against actual realisations been performed? (backtesting)				
To what extent has a range of outputs been examined vs. a range of inputs (e.g. are solutions continuous or jagged? What is the behaviour of hedging quantities and/or derived quantities over the same range?)				
To what extent are all results repeatable? (e.g. Monte Carlo simulations)				
Monitoring				
To what extent has the model been monitored for appropriate implementation and use?				
To what extent has the model been monitored to check whether it is performing as intended?				