Test Plan & Result

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i. Data Validation

1. Data Source

We obtained the stock prices of Apple, IBM, UPS, and General Electric from Bloomberg and the implied volatility of the corresponding close to at-the-money calls and puts from Yahoo Finance. The time range is from Dec 15th 1980 to Oct 28th 2014.

2. Data Cleaning and Structuring

We restructured the data in the csv format; the first column is the date and the following columns correspond to the prices of each stock and option. The first row is the name of the variables. We also double checked for missing values and ensured the used data were clean.

ii. Design and Purpose of the Test Plan

1. Design and Theoretical Validation Testing

1) **Input 1:** A portfolio consists of AAPL and IBM and long position only. This is used to test for calculation validity of mean, standard deviation, VaR and ES by comparing our outputs with homework solutions provided by professor Harvey J. Stein in the course MATH G4082 Risk Management and Regulation.
2) **Input 2:** A portfolio consists of long AAPL and short IBM. This is used to test for the validity of the model as well. Since we've found out there is positive correlation between AAPL and IBM, if we compare the Input 2 with Input 1, the VaR/ES is expected to be lower to reflect a lower level of risk exposure.
3) **Input 3:** A portfolio consists of AAPL, IBM, UPS and GE and long position only. This is to test whether the model is valid for a portfolio of multiple stocks.
4) **Input 4:** A portfolio consists of shorting AAPL and UPS, longing IBM, GE and calls of AAPL and UPS and puts of IBM and GE, both long and short positions allowed. This is to test whether the model is valid for the more practical case and a wider application by allowing for both stocks and options and long and short positions.

2. Robustness Testing

1) Extreme Market Conditions for Stress Testing

Based on the output of Input 1, we specially extracted the period from Jan 1st 2008 to Dec 31st 2010. The period is known for suffering from great financial crisis and under intense market stress.

2) Large Range of Inputs

We utilized input of range from single digit price to the hundred level which has covered a wide range of input values.

iii. Test Assumption and Limitation

Our key assumption is that the data we utilized are clean and there are no missing values. Besides, we also assumed that the value of the portfolio to be equal to $100 million for comparison, which is not necessary for the system users. We tested for 99% 5-day VaR and 97.5% 5-day ES, but if users of the system want to change the input, they could access the interface and set their requirements for evaluating different risk exposure levels as well as different time windows.

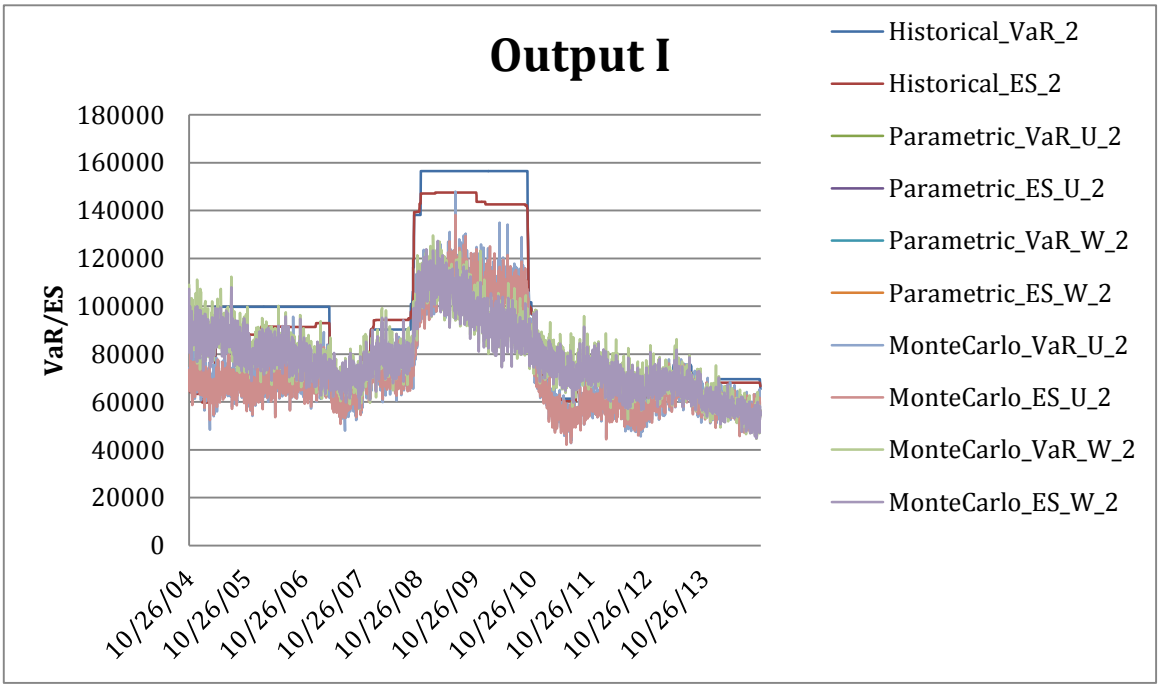
iv. Output

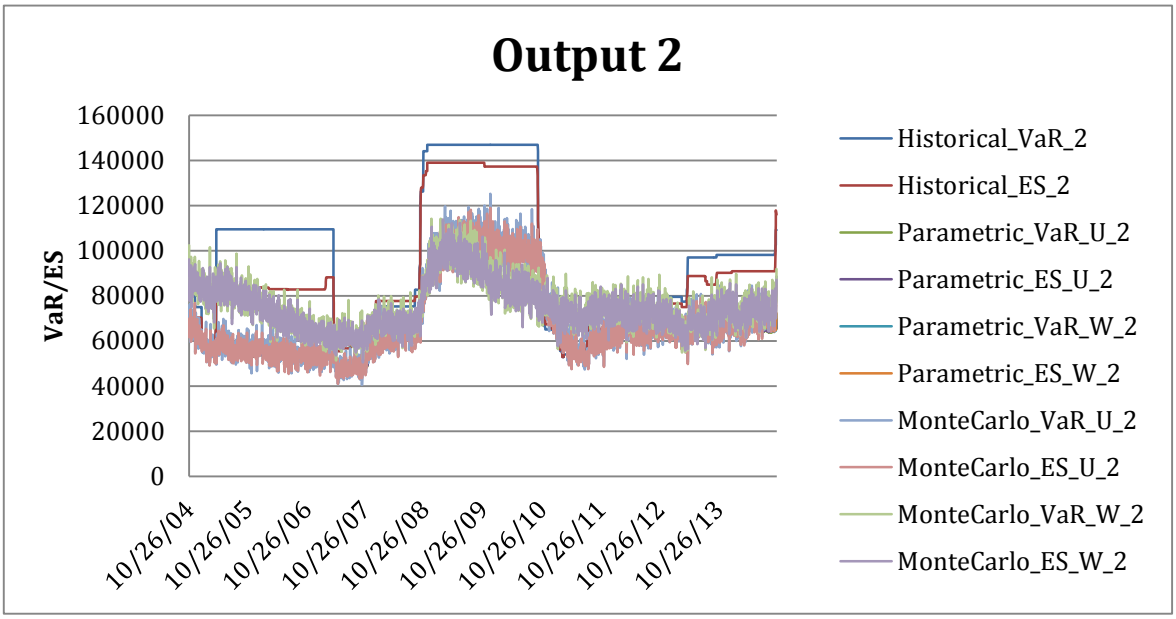
The outputs of each of the input are shown in the following graphs. Output 1 and the intermediated parameters, mean and standard deviation, do match the official homework solutions, proving the validity of the fundamentals of the calculation system. When comparing Output 1 and Output 2, we also see that all the VaR results are higher in Output 1, which is in line with our expectation that since AAPL and IBM are positively correlated, the opposite position in these stocks should form a portfolio with lower risk exposure. As for stress testing, we specially listed out the period of Jan 1st 2008 to Dec 31st 2010 to compute for the accuracy of the computed VaR. The results are very similar to the rest of the period, suggesting the robustness of the system. Further details of the accuracy level are reported in section v. According to the result of Input3.csv, 99% VaR is very close to 97.5% ES among all three methods, which validates the accuracy of our system.

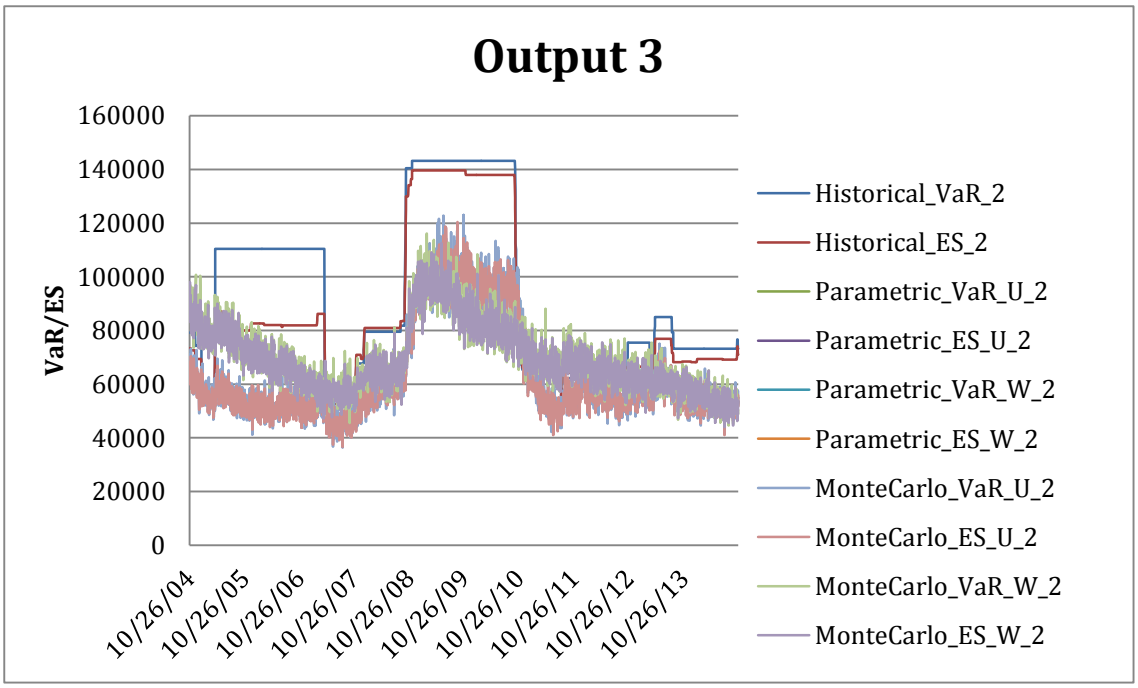
Historical_VaR_2	Historical_ES_2
73173.1849	71120.21945
73173.1849	71120.21945
73173.1849	71120.21945
73173.1849	71120.21945
73173.1849	71120.21945
73173.1849	71120.21945
73173.1849	71120.21945
76718.26997	74038.02904
76718.26997	73222.97497
76718.26997	73866.25051
76718.26997	72217.3664
73173.1849	69986.85053
73173.1849	69117.88956
73173.1849	69117.88956
73173.1849	69117.88956
73173.1849	69117.88956
73173.1849	69117.88956
73173.1849	69117.88956
73173.1849	69117.88956
73173.1849	69117.88956

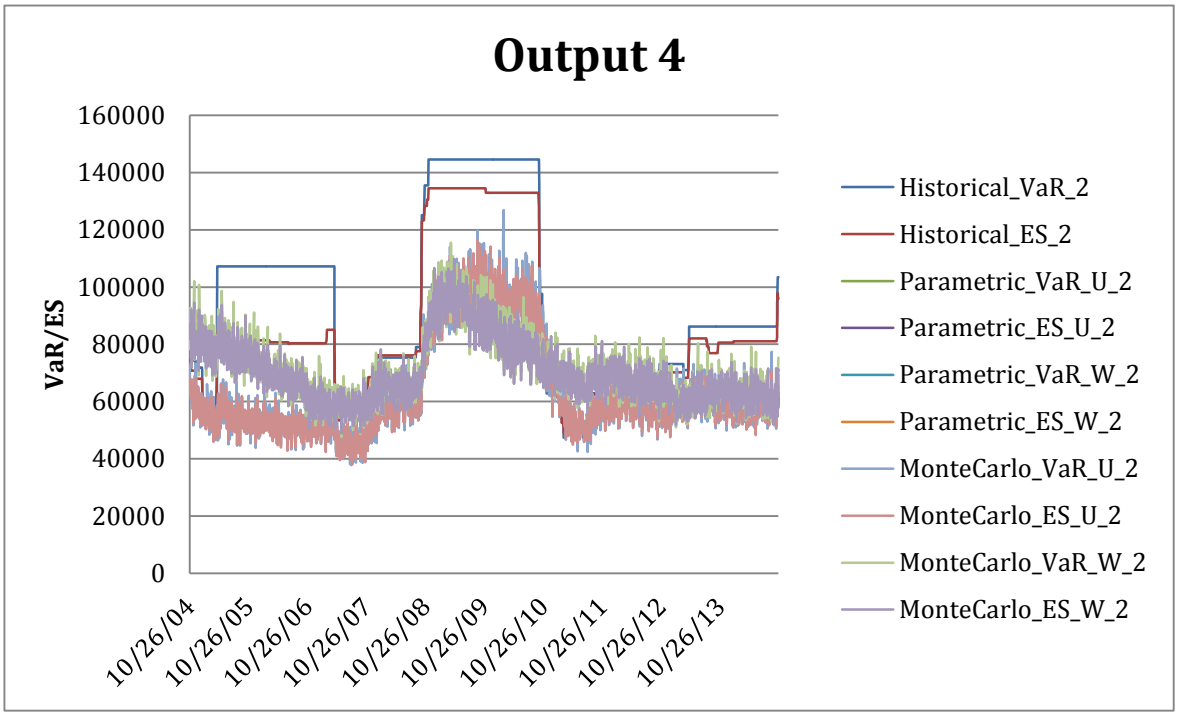
Parametric_VaR_U_2	Parametric_ES_U_2	Parametric_VaR_W_2	Parametric_ES_W_2
51435.93281	51652.65458	54517.16458	54748.33081
51801.1127	52018.47111	54639.97995	54871.07382
51765.12027	51982.77091	54688.39774	54919.71501
52032.74463	52250.61272	54757.96513	54989.50387
52559.78779	52778.76682	54873.13469	55104.80132
53419.93449	53641.16573	54863.27181	55095.12496
51681.8353	51899.14017	54504.32642	54735.75319
51683.4046	51900.4711	52569.78265	52796.62816
51474.3568	51691.37789	52687.90033	52914.62656
51351.83864	51568.67982	52547.93106	52774.65384
51423.96532	51640.87026	52400.13485	52626.84047
51340.88564	51557.65003	52442.80958	52669.73461
51408.15712	51624.99307	52278.11465	52504.99259
51277.54196	51494.19118	52301.7548	52528.84362
51290.76745	51506.69199	52153.02288	52380.0934
50986.90265	51202.50333	52227.13645	52453.64096
51018.08356	51233.67812	51964.47186	52190.73833
51013.75285	51229.42276	52039.71699	52266.19762
51006.71139	51222.38638	52151.68156	52378.29034
50726.97359	50942.61194	52217.90388	52444.73185

MonteCarlo_VaR_U_2	MonteCarlo_ES_U_2	MonteCarlo_VaR_W_2	MonteCarlo_ES_W_2
52935.51582	53939.08581	54873.1188	54346.46661
48377.07856	47458.26226	50026.7547	50745.31091
48582.23665	48740.1486	46366.74433	47704.46255
51506.36346	49611.41567	52016.05126	52329.22144
53929.06637	54434.23884	49087.73683	47734.32666
52828.58722	51788.12059	50448.34081	53865.93915
57640.74769	56047.71965	48681.63187	48916.49158
51148.74175	48219.776	50666.27591	50440.67752
51095.96112	50035.84263	49696.08925	49785.05221
57876.3587	56134.3391	46623.78449	46221.41889
51020.81429	51964.70108	53680.51447	53477.08386
51478.90179	50443.38461	55338.91836	52910.25696
52893.49006	52481.90374	58239.51844	54453.58035
50787.08307	51061.42959	49696.60157	50412.53084
48527.26132	49083.56434	55133.86973	55019.83297
54671.9666	55237.90915	50325.85771	48835.10549
49899.76318	47607.01114	51935.2624	50671.86744
51290.49159	51903.27115	50564.92801	49991.65194
50245.6575	49838.71274	48825.31554	51298.47061
60635.86733	56032.85979	56756.48787	58760.74085




Output 2
VaR/ES
160000
140000
120000
100000
80000
60000
40000
20000
0
10/26/04
10/26/05
10/26/06
10/26/07
10/26/08
10/26/09
10/26/10
10/26/11
10/26/12
10/26/13
Historical_VaR_2
Historical_ES_2
Parametric_VaR_U_2
Parametric_ES_U_2
Parametric_VaR_W_2
Parametric_ES_W_2
MonteCarlo_VaR_U_2
MonteCarlo_ES_U_2
MonteCarlo_VaR_W_2
MonteCarlo_ES_W_2


Output 3
VaR/ES
160000
140000
120000
100000
80000
60000
40000
20000
0
10/26/04
10/26/05
10/26/06
10/26/07
10/26/08
10/26/09
10/26/10
10/26/11
10/26/12
10/26/13
Historical_VaR_2
Historical_ES_2
Parametric_VaR_U_2
Parametric_ES_U_2
Parametric_VaR_W_2
Parametric_ES_W_2
MonteCarlo_VaR_U_2
MonteCarlo_ES_U_2
MonteCarlo_VaR_W_2
MonteCarlo_ES_W_2



v. System Validation

We evaluated the system validation by the accuracy of 99% 5-day VaR. The percentage of loss that are lower than the VaR for different inputs are reported in the following table. We do observe that historical VaRs are the most accurate, whereas the results are not bad for the remaining two approaches as well, which are all within the 2% difference from 99%. Also this result justifies our hypothesis that Monte Carlo simulation and parametric methodology under GBM assumption underestimate VaR, but it is not that serious.

Loss lower than VaR %	**Output 1**	**Output 2**	**Output 3**	**Output 4**
Historical VaR	98.89%	98.33%	98.69%	98.33%
Parametric VaR (U)	98.01%	96.86%	97.57%	97.18%
Parametric VaR (W)	98.41%	97.57%	98.01%	97.85%
MonteCarlo VaR (U)	98.09%	97.34%	97.57%	97.26%
MonteCarloVaR(W)	98.49%	97.89%	98.05%	97.97%