Case Study Two

Requirements

The second case study focuses on the stock market, and takes a look at ten large companies' monthly stock returns for the previous year (Nov 2017 – Oct 2018). The companies whose stocks I looked at are: Tesla (Uk.finance.yahoo.com, 2018), Google (Uk.finance.yahoo.com, 2018), Facebook (Uk.finance.yahoo.com, 2018), Microsoft (Uk.finance.yahoo.com, 2018), Amazon (Uk.finance.yahoo.com, 2018), Twitter (Uk.finance.yahoo.com, 2018), NVIDIA (Uk.finance.yahoo.com, 2018), and Apple (Uk.finance.yahoo.com, 2018). I retrieved all the stock data from Yahoo Finance to help ensure consistency throughout my calculation.

In order to calculate how to optimise the investment in each stock, I had to complete a few calculations using the stock data first. To calculate the returns, I deducted the stock price of each month, from the stock price of the previous month, with the first month's returns being calculated from the stock prices of 01/12/2017 taken away from the stock prices of 01/11/2017 and then divided by the stock prices of 01/11/2017 to create a percentage value.

Using Tesla's Stocks as an example, I performed (311.35 - 308.85) ÷ 308.85 = 0.81

With all the monthly returns on the stocks calculated, I then used Excel's AVERAGE function to calculate the Expected Return for each stock, using the return values calculated previously.

Using Tesla's Returns as an example, this is performed by entering =AVERAGE(K2:K12)

With these values calculated, I could then calculate the Monthly Portfolio Return, the Max Loss, and the Portfolio Risk. The Max loss was calculated in a similar way to calculating the Expected Return, using Excel's MIN function. In order to prevent negative values in the Max Loss field, I placed a minus symbol in front of the MIN function.

Using Tesla's Max Loss as an example, this is performed by entering =-MIN(K2:K12)

The Monthly Portfolio Return is calculated using the value of the relevant Weights field multiplied by the relevant Expected Return field.

*Using Tesla's Monthly Portfolio Return as an example, I calculated 1.25% * -0.83% = -0.01%*

Finally, the Portfolio Risk is calculated by the stock's Max Loss multiplied by the stock's Weights.

*Using Tesla's Portfolio Risk as an example, I calculated 22.42% * 1.25%*

The Weights for each stock are calculated using Excel Solver which would then update the Monthly Portfolio Return and the Portfolio Risk columns automatically.

I created some constraints that I wanted Excel Solver to follow during the calculation:

- Monthly portfolio return is greater than or equal to 2.5%
- The portfolio risk should be minimised and less than or equal to 7.5%
- The minimum stock investment should be greater than or equal to 1.25%
- The maximum stock investment per stock should be less than or equal to 45%
- Apple must have an investment amount of less than or equal to 25%
- The amount invested must equal 100%

The constraints I created above were selected to prevent Excel's Solver from investing the full amount into Apple's stocks (which provided the highest estimated monthly return). Having a monthly portfolio return of 2.5% on your investment is a huge return per month, totalling at an estimated yearly return of 30% - a return amount any investor would be more than happy with. I selected to minimise the portfolio risk to be less than or equal to 7.5% as this keeps the chances of having a loss on your investment low enough to encourage investment, but also not low enough to prevent you from maximising your potential profit. I wanted to force the Solver to place at least 1.25% of the maximum investment in all stocks, this prevented the investment being spread across only two stocks, something potentially risky if one of the businesses invested in becomes bankrupt.

I also stated that the maximum investment in any stock should be capped to 45% and that Apple's investment must be equal to or less than 25%. These decisions were made to prevent any heavy weighting, and enable Solver the best chance to balance the investments fairly across multiple stocks rather than just one or two. Apple's stock provided the most profit for the lowest risk, so if an investor wanted to invest into any one stock from my portfolio, then Apple would be the easy choice; however, I wanted to have the investment amount spread out and not favour Apple as heavily in order to see what stocks Solver would favour if it was not allowed to fully invest in Apple.

Decision Variables

Using these constraints, I was able to create these decision variables:

x1 = Monthly portfolio return

x2 = The minimised portfolio risk

x31 = The amount invested in Tesla

x32 = The amount invested in Google

x33 = The amount invested in Facebook

x34 = The amount invested in Microsoft

x35 = The amount invested in Amazon

x36 = The amount invested in Twitter

x37 = The amount invested in NVIDIA

x38 = The amount invested in Apple

Mathematical Model

The aim is to minimise the portfolio risk while maximising the monthly portfolio return:

Amount Invested (Weights) = w

Monthly Portfolio Return = pr

Portfolio Risk = r

Expected Return (average return from previous year) = e

Max Loss (minimum return from previous year) = l

$w = x31 + x32 + x33 + x34 + x35 + x36 + x37 + x38$

$pr = w*e$

$r = l*w$

Constraints

x11																x1		>=	2.5%
x21																	x2	<=	7.5%
x31	x31	+	x32	+	x33	+	x34	+	x35	+	x36	+	x37	+	x38			=	100%
x41															x38			<=	25%
x51	x31																	>=	1.25%
x61	x31																	<=	45%
x52			x32															>=	1.25%
x62			x32															<=	45%
x53					x33													>=	1.25%
x63					x33													<=	45%
x54							x34											>=	1.25%
x64							x34											<=	45%
x55									x35									=>	1.25%
x65									x35									<=	45%
x56											x36							=>	1.25%
x66											x36							<=	45%
x57													x37					=>	1.25%
x67													x37					<=	45%
x58															x38			=>	1.25%
x68															x38			<=	45%

Summarised Results

Constraint	Tesla Weight x31	Google Weight x32	Facebook Weight x33	Microsoft Weight x34	Amazon Weight x35	Twitter Weight x36	NVIDIA Weight x37	Apple Weight x38	Monthly Portfolio Return x1	Portfolio Risk x2	Total
x11									2.5%		2.5%
x21										7.14%	7.14%
x31	1.25%	12.35%	1.25%	45%	12.65%	1.25%	1.25%	25%			100%
x41								25%			25%
x51	1.25%										1.25%
x52		12.35%									12.35%
x53			1.25%								1.25%
x54				45%							45%
x55					12.65%						12.65%
x56						1.25%					1.25%
x57							1.25%				1.25%
x58								25%			25%
x61	1.25%										1.25%
x62		12.35%									12.35%
x63			1.25%								1.25%
x64				45%							45%
x65					12.65%						12.65%
x66						1.25%					1.25%
x67							1.25%				1.25%
x68								25%			25%

Results with Microsoft Excel

Date	Tesla TSLA	Google GOOGL	Facebook FB	Microsoft MSFT	Amazon AMZN	Twitter TWTR	NVIDIA NVDA	Apple AAPL
01/11/2017	308.85	1036.17	177.18	82.67991	1176.75	20.58	211.0857	169.2903
01/12/2017	311.35	1053.4	176.46	84.44764	1169.47	24.01	193.1546	167.3086
01/01/2018	354.31	1182.22	186.89	93.79671	1450.89	25.81	245.3613	165.5291
01/02/2018	343.06	1103.92	178.32	92.57254	1512.45	31.86	241.5681	176.0977
01/03/2018	266.13	1037.14	159.79	90.52773	1447.34	29.01	231.3203	166.5514
01/04/2018	293.9	1018.58	172	92.75943	1566.13	30.31	224.6381	164.0498
01/05/2018	284.73	1100	191.78	98.03616	1629.62	34.7	251.8963	185.5016
01/06/2018	342.95	1129.19	194.32	98.23198	1699.8	43.67	236.7705	184.4631
01/07/2018	298.14	1227.22	172.58	105.6733	1777.44	31.87	244.7261	189.625
01/08/2018	301.66	1231.8	175.73	111.8994	2012.71	35.18	280.5266	226.8345
01/09/2018	264.77	1207.08	164.46	114.37	2003	28.46	281.02	225.74
01/10/2018	260	1105.18	154.05	108.66	1764.03	28.83	229.17	219.31

Returns TSLA	Returns GOOGL	Returns FB	Returns MSFT	Returns AMZN	Returns TWTR	Returns NVDA	Returns AAPL
0.81%	1.66%	-0.41%	2.14%	-0.62%	16.67%	-8.49%	-1.17%
13.80%	12.23%	5.91%	11.07%	24.06%	7.50%	27.03%	-1.06%
-3.18%	-6.62%	-4.59%	-1.31%	4.24%	23.44%	-1.55%	6.38%
-22.42%	-6.05%	-10.39%	-2.21%	-4.30%	-8.95%	-4.24%	-5.42%
10.43%	-1.79%	7.64%	2.47%	8.21%	4.48%	-2.89%	-1.50%
-3.12%	7.99%	11.50%	5.69%	4.05%	14.48%	12.13%	13.08%
20.45%	2.65%	1.32%	0.20%	4.31%	25.85%	-6.00%	-0.56%
-13.07%	8.68%	-11.19%	7.58%	4.57%	-27.02%	3.36%	2.80%
1.18%	0.37%	1.83%	5.89%	13.24%	10.39%	14.63%	19.62%
-12.23%	-2.01%	-6.41%	2.21%	-0.48%	-19.10%	0.18%	-0.48%
-1.80%	-8.44%	-6.33%	-4.99%	-11.93%	1.30%	-18.45%	-2.85%

Stock	Weights	Expected Return	Monthly Portfolio Return	Max Loss	Portfolio Risk
TSLA	1.25%	-0.83%	-0.01%	22.42%	0.28%
GOOGL	12.35%	0.79%	0.10%	8.44%	1.04%
FB	1.25%	-1.01%	-0.01%	11.19%	0.14%
MSFT	45.00%	2.61%	1.18%	4.99%	2.25%
AMZN	12.65%	4.12%	0.52%	11.93%	1.51%
TWTR	1.25%	4.46%	0.06%	27.02%	0.34%
NVDA	1.25%	1.43%	0.02%	18.45%	0.23%
AAPL	25.00%	2.62%	0.66%	5.42%	1.36%
Total	**100.00%**		**2.50%**		**7.14%**

Figure 3 - The Excel spreadsheet used alongside Excel's Solver to optimise the monthly portfolio return

Microsoft Excel 14.0 Answer Report
Worksheet: [Case Study 2.xlsx]Sheet1
Report Created: 22/10/2018 15:11:21
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.
Solver Engine
Engine: Simplex LP
Solution Time: 0.015 Seconds.
Iterations: 7 Subproblems: 0
Solver Options
Max Time Unlimited, Iterations Unlimited, Precision 0.000001, Use Automatic Scaling
Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Min)

Cell	Name	Original Value	Final Value
L25	Total Portfolio Risk	13.73%	7.14%

Variable Cells

Cell	Name	Original Value	Final Value	Integer
H17	TSLA Weights	12.50%	1.25%	Contin
H18	GOOGL Weights	12.50%	12.35%	Contin
H19	FB Weights	12.50%	1.25%	Contin
H20	MSFT Weights	12.50%	45.00%	Contin
H21	AMZN Weights	12.50%	12.65%	Contin
H22	TWTR Weights	12.50%	1.25%	Contin
H23	NVDA Weights	12.50%	1.25%	Contin
H24	AAPL Weights	12.50%	25.00%	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
H25	Total Weights	100.00%	H25=1	Binding	0
J25	Total Monthly Portfolio Return	2.50%	J25>=0.025	Binding	0.00%
L25	Total Portfolio Risk	7.14%	L25<=0.075	Not Binding	0.003578949
H17	TSLA Weights	1.25%	H17<=0.45	Not Binding	0.4375
H18	GOOGL Weights	12.35%	H18<=0.45	Not Binding	0.326458209
H19	FB Weights	1.25%	H19<=0.45	Not Binding	0.4375
H20	MSFT Weights	45.00%	H20<=0.45	Binding	0
H21	AMZN Weights	12.65%	H21<=0.45	Not Binding	0.323541791
H22	TWTR Weights	1.25%	H22<=0.45	Not Binding	0.4375
H23	NVDA Weights	1.25%	H23<=0.45	Not Binding	0.4375
H24	AAPL Weights	25.00%	H24<=0.45	Binding	0
H17	TSLA Weights	1.25%	H17>=0.0125	Binding	0.00%
H18	GOOGL Weights	12.35%	H18>=0.0125	Not Binding	11.10%
H19	FB Weights	1.25%	H19>=0.0125	Binding	0.00%
H20	MSFT Weights	45.00%	H20>=0.0125	Not Binding	43.75%
H21	AMZN Weights	12.65%	H21>=0.0125	Not Binding	11.40%
H22	TWTR Weights	1.25%	H22>=0.0125	Binding	0.00%
H23	NVDA Weights	1.25%	H23>=0.0125	Binding	0.00%
H24	AAPL Weights	25.00%	H24>=0.0125	Not Binding	23.75%
H24	AAPL Weights	25.00%	H24<=0.25	Binding	0

Figures 4 & 5 - The results generated from running Excel Solver on my spreadsheet

Conclusion

My results from my second case study show that Excel's Solver invested the constrained maximum amount into Apple and Microsoft as they produced the most monthly return on investment for the lowest risk. This was an expected result due to the good reputation these companies have when it comes to turning over a quarterly profit and staying relevant leaders in the growing tech market. I was surprised to see that Solver did not favour Tesla as a company. I believe that while Tesla is prominent in social media, it is a risky investment for investors due to how volatile Tesla's stocks have been proven to be. This was an interesting case study as Solver was not influenced by any of the company's online presences, and only took into account the information gathered from Yahoo Finance.