Master in Management (Business Analytics, January 2023 Intake)

PRESCRIPTIVE ANALYTICS: OPTIMISING DATA-DRIVEN DECISIONS

(Risk Analysis Assignment)

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Introduction:
This report provides a financial risk analysis for BHR's proposed acquisition of Vulcan, a small mining company with zinc, copper, and lead divisions. The analysis is based on a Net Present Value (NPV) model that takes into account the expected production quantities, operating costs, and metal prices for each division, as well as the corporate tax rate and the after-tax discount rate.

Part I: Base Case Model
The base case model *(Appendix A)* represents the most likely scenario and assumes that Vulcan will produce 10,000 tonnes of copper, 200 tonnes of lead, and 500 tonnes of zinc per annum. Operating costs are assumed to be $4,500 per tonne for copper, $2,800 per tonne for lead, and $2,100 per tonne for zinc. Prices are assumed to be $5,200 per tonne for copper, $2,800 per tonne for lead, and $2,200 per tonne for zinc. Fixed costs are assumed to be $1 million for the zinc division, $250,000 for the lead division, and $3 million for the copper division. The model uses a corporate tax rate of 35% and an after-tax discount rate of 9.66%. The base case model estimates an NPV of $7,093,416.17. This base model is a stationary approach, not considering uncertainties and risks. Therefore, BHR should not base decisions on these calculations.

Constraints, Objectives, and Decision Variables
The model for BHR's proposed acquisition of Vulcan is subject to constraints including production quantities, operating costs, and metal prices. The goal is to calculate the acquisition's NPV, with the discount rate as the **primary decision variable**. BHR can adjust this rate based on its cost of capital and risk tolerance, considering a range between 7% and 11%. Future parts of this report will conduct scenario and sensitivity analyses, and simulations and evaluate the impact of varying the discount rate on the NPV.

Part II: Scenario Analysis
In our scenario analysis *(Appendix B)* for Project Vulcan, we considered optimistic, base, and pessimistic scenarios. The optimistic scenario, with higher production volumes, lower operating costs, and higher commodity prices, yields a positive NPV of $50,516,212.54, indicating high profitability. The base scenario, representing the **most likely outcome**, also yields a positive but lower NPV of $7,093,416.17. The pessimistic scenario, with lower production volumes, higher operating costs, and lower commodity prices, results in a negative NPV of -$44,334,807.02, indicating a substantial loss. The wide NPV range across scenarios underscores the significant financial risks and uncertainties in Project Vulcan's profitability. Further sensitivity and risk analyses are conducted to delve deeper into these aspects.

Part III: Sensitivity analysis
In our sensitivity analysis, we used a tornado analysis *(Appendix C)* to identify the key variables that have the most significant impact on the Net Present Value (NPV) of Project Vulcan. The results showed that the **operating cost** and **price of copper** are the **two most uncertain variables**.

In a **one-way sensitivity analysis *(Appendix D.1)***, we examined the impact of each variable individually on the NPV. We found that an increase in the operating cost of copper from $3,800 to $5,500 per tonne leads to a decrease in the NPV from $24,492,361.48 to -$17,762,219.99 *(Appendix D.1)*. This indicates that higher operating costs could potentially turn the investment into a loss-making proposition. On the other hand, an increase in the price of copper from $4,500 to $5,500 per tonne results in an increase in the NPV from -$10,305,529.15 to $14,550,107.01 *(Appendix D.2)*. This suggests that higher copper prices could significantly enhance the profitability of the investment.
In a **two-way sensitivity analysis (*Appendix E)***, we examined the combined impact of the operating cost and price of copper on the NPV. The results showed that the NPV is highly sensitive to both variables. An increase in the operating cost of copper significantly reduces the NPV, indicating that

any inefficiencies in the production process or unexpected increases in production costs could negatively impact the profitability of the project. Conversely, higher copper prices lead to increased revenues and a higher NPV, suggesting that the project's profitability could greatly benefit from favourable market conditions. However, the sensitivity to the price of copper also exposes the project to the risk of copper price volatility.

The heatmap in *Appendix E* provides a visual representation of these relationships. As the "Change in Price of Copper" increases, the output generally increases, as indicated by the shift in colour from red to green. Conversely, as the "Change in Operating Cost" increases, the output decreases, as indicated by the shift in colour from green to red. This visualisation can provide valuable insights for decision-making, underscoring the importance of strategic planning and risk management in ensuring the success of the acquisition and the profitability of the project. BHR should focus on cost management and monitor copper prices. Hedging strategies could mitigate price volatility risks. Timing the investment strategically can optimise profitability.

Part IV: @Risk Simulation *(APPENDIX- F)*

The *Monte Carlo Simulation on @Risk* was utilised to assess the potential risks and rewards associated with the acquisition of Vulcan's mining divisions. The simulation provided a range of possible outcomes based on the uncertainty inherent in the key variables.

The **mean Net Present Value (NPV)** from the simulation is approximately $3,305,708.32. This positive average NPV indicates that, on average, the expected cash inflows from the acquisition discounted back to the present value are greater than the expected cash outflows, suggesting that the acquisition could potentially add value to BHR.

However**, the 90% confidence interval** for the NPV ranges from -$20,727,564.95 to $27,045,998.30. This wide range indicates a significant level of uncertainty surrounding the project's profitability. It suggests that while the project has the potential to generate substantial profits, there is also a risk of substantial losses.

The simulation results show that the probability of the NPV **exceeding $8 million** is approximately 10%. This would indicate a highly successful outcome for the acquisition. It represents the best-case scenario and the potential for substantial profit. Conversely, the **probability of the NPV being negative** is approximately 40%, which would mean that the expected costs of the acquisition exceed the expected benefits. The downside risk is particularly significant, with a 5% chance that the NPV could be less than -$20,727,564.95. In essence, the upside and downside potentials provide a measure of the risk and reward associated with the acquisition *(Appendix F)*.

Input Assumptions:

In the simulation, the production quantities and prices for each division (copper, lead, and zinc) were modelled using triangular distributions, and the operating prices were modelled using cumulative distributions. These distributions were used to generate a range of possible outcomes for each variable, which were then used to calculate the NPV under different scenarios.

Based on the simulation results, there is a significant degree of uncertainty and risk associated with the acquisition of Vulcan. While the average NPV is positive, suggesting the acquisition could add value to BHR, the wide range of possible NPVs indicates a substantial risk of losses.

The simulation results provide BHR with valuable insights into the potential risks and rewards of the acquisition, which can inform their decision-making process. In the end, their strategic decision should depend on their risk tolerance and also alternative investment opportunities (that might have different risk profiles).

Part V: @Risk Simulation Model with Correlation: *(APPENDIX G)*

The new simulation results *(Appendix G.1)* show that the **minimum NPV has decreased** from -$37,838,849.76 to -$31,447,625.15, and **the maximum NPV has increased** from $36,894,549.40 to $42,154,067.28. This suggests that while the worst-case scenario has improved, the best-case scenario has also become more favourable. The ***90% confidence interval*** for the NPV is now between -$21,032,261.68 and $26,022,595.09. This range is narrower than in the previous simulation, indicating that the uncertainty and risk associated with the acquisition have *decreased slightly (Appendix- G.1)*.

The ***average NPV,*** has slightly increased from the previous simulation, moving from $3,305,708.32 to $3,317,397.60. This **increase in the average NPV** suggests that, on average, the expected cash inflows from the acquisition discounted back to the present value are slightly higher than in the previous simulation. This indicates that the acquisition could, on average, add slightly more value to BHR than previously estimated.

However, the 5% percentile value (the value below which 5% of the observations may be found) has increased to -$21,032,261.68 from the previous -$20,727,564.95, indicating a **higher downside risk** in most scenarios. *The standard deviation*, a measure of risk, has decreased to $14,610,141.32 from the previous $15,083,132.37, indicating that the project's returns are expected to be *slightly less volatile* (*Appendix G.2).*

The changes in the input parameters (production quantities, operating costs, and prices) reflect the updated correlations between the prices of copper, lead, and zinc. These correlations were used to refine the model and provide a more accurate representation of the market conditions.

Our recommendation would be to *consider the acquisition of Vulcan* more favourably than in the previous analysis. The increased average NPV, combined with the upside potential, suggests that the acquisition could add value to BHR. However, the decision should still be made in the context of BHR's risk tolerance and strategic objectives, and we will do further analyses by changing the decision variable i.e., *Discount Rate* to refine the assumptions and mitigate the identified risks.

Part VI: Further refinement of @Risk Simulation Model and Recommendations: (Appendix H)

The @Risk Simulation model was further refined by considering a range of discount rates from 7% to 11%. The aim was to provide a robust evaluation of the project's financial viability and to identify any significant trends or changes across the different simulations. By adjusting the discount rate, BHR can affect perceived risk and required returns, potentially enhancing the present value of future cash flows and making the business seem less risky to stakeholders.

The NPV simulations reveal a wide range of potential NPVs, indicating that the project's profitability is highly sensitive to changes in the discount rate and other factors. The mean NPV shows a slight downward trend as the discount rate increases, suggesting that the expected profitability of the project decreases as the discount rate increases. The standard deviation of the NPV, which measures the spread of the NPV values around the mean, decreases as the discount rate increases, indicating that the variability of the NPV decreases as the discount rate increases. (Appendix H)

Recommendation:

Based on the range of discount rates and the trends observed in the NPV simulations, a balanced discount rate would be one that maximizes the NPV while also taking into account the inherent risks of the project.

According to us, **a discount rate of 9% seems to strike a good balance**. Upon comparing the discount rates of 9% and 9.66%, it is evident that a 9% rate offers a more balanced choice for Project Vulcan. This is due to a **higher mean NPV of $3,272,142.67** ***(Appendix H),*** suggesting a greater average return on investment. Additionally, the standard deviation at 9% is lower indicating **less risk** or uncertainty in the expected return. The skewness at 9% is less negative (-0.1471), implying a lower probability of negative returns. Furthermore, the median NPV at 9% ($4,049,059.41) is higher, indicating that at least 50% of the NPV values are higher at this rate. ***Therefore, a 9% discount rate***

provides a higher expected return with less risk, making it a more balanced choice for Project Vulcan.

Appendices:

(Please note that numbers in appendices are in Indian format. In the report we transformed the formatting to US standard.)

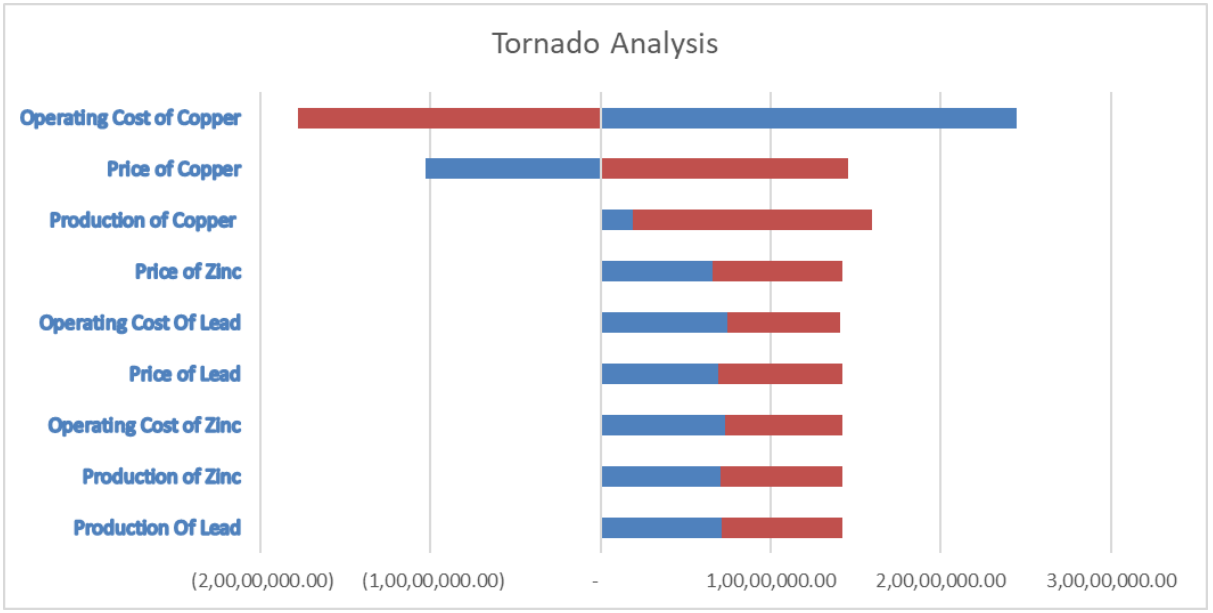
APPENDIX A (Base Model)

Project Vulcan	
	Base
Parameters	
Production (tonnes):	
Copper tonnes	**10,000**
Lead tonnes	**200**
Zinc tonnes	**500**
Remaining life	**5**
Fixed Costs:	
Fixed costs Zinc	**1000000**
Fixed costs Lead	**250000**
Fixed costs Copper	**3000000**
Corporate Tax Rate	**35%**
After tax discount rate	**9.66%**
Operating Costs ($/ tonne):	
Copper op cost	**$4,500**
Lead op cost	**$2,800**
Zinc op cost	**$2,100**
Prices ($/tonne):	
Copper	**$5,200**
Lead	**$2,800**
Zinc	**$2,200**
Profit & Loss	
Revenue from copper	**$5,20,00,000**
Revenue from lead	**$5,60,000**
Revenue from zinc	**$11,00,000**
Total revenue:	**$5,36,60,000**
Operating costs copper	**$4,50,00,000**
Operating costs lead	**$5,60,000**
Operating costs zinc	**$10,50,000**
Total operating costs	**$4,66,10,000**
Fixed Costs	**4250000**
Total Cost	**$5,08,60,000**
EBITDA	**$28,00,000**
DA	**100000**
EBIT	**$27,00,000**
Interest	**0**
EBT	**$27,00,000**
Tax	**$9,45,000**
Earnings	**$17,55,000**
FCF derivation:	
EBITDA	**$28,00,000**
tax	**$9,45,000**
interest	**0**
Change in working capital	**0**
FCF	**$18,55,000**
Net Present Value	**$70,93,416.17**

APPENDIX B (Scenario Analysis)

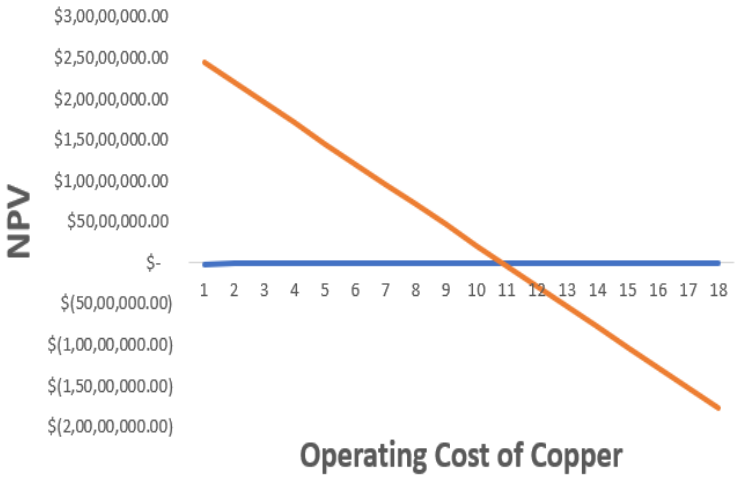
Project Vulcan			
	Optimistic	Base	Pessimistic
Parameters			
Production (tonnes):			
Copper tonnes	14,000	10,000	7,000
Lead tonnes	300	200	80
Zinc tonnes	600	500	400
Remaining life	5	5	5
Fixed Costs:			
Fixed costs Zinc	1000000	1000000	1000000
Fixed costs Lead	250000	250000	250000
Fixed costs Copper	3000000	3000000	3000000
Corporate Tax Rate	35%	35%	35%
After tax discount rate	9.66%	9.66%	9.66%
Operating Costs ($/ tonne):			
Copper op cost	$3,800	$4,500	$5,500
Lead op cost	$2,400	$2,800	$3,200
Zinc op cost	$1,800	$2,100	$2,500
Prices ($/tonne):			
Copper	$5,500	$5,200	$4,500
Lead	$3,200	$2,800	$2,400
Zinc	$2,600	$2,200	$1,800
Profit & Loss			
Revenue from copper	$7,70,00,000	$5,20,00,000	$3,15,00,000
Revenue from lead	$9,60,000	$5,60,000	$1,92,000
Revenue from zinc	$15,60,000	$11,00,000	$7,20,000
Total revenue:	$7,95,20,000	$5,36,60,000	$3,24,12,000
Operating costs copper	$5,32,00,000	$4,50,00,000	$3,85,00,000
Operating costs lead	$7,20,000	$5,60,000	$2,56,000
Operating costs zinc	$10,80,000	$10,50,000	$10,00,000
Total operating costs	$5,50,00,000	$4,66,10,000	$3,97,56,000
Fixed Costs	4250000	4250000	4250000
Total Cost	$5,92,50,000	$5,08,60,000	$4,40,06,000
EBITDA	$2,02,70,000	$28,00,000	-$1,15,94,000
DA	100000	100000	100000
EBIT	$2,01,70,000	$27,00,000	-$1,16,94,000
Interest	0	0	0
EBT	$2,01,70,000	$27,00,000	-$1,16,94,000
Tax	$70,59,500	$9,45,000	0
Earnings	$1,31,10,500	$17,55,000	-$1,16,94,000
FCF derivation:			
EBITDA	$2,02,70,000	$28,00,000	-$1,15,94,000
tax	$70,59,500	$9,45,000	0
interest	0	0	0
Change in working capital	0	0	0
FCF	$1,32,10,500	$18,55,000	-$1,15,94,000
Net Present Value	$5,05,16,212.54	$70,93,416.17	$ -4,43,34,807.02

APPENDIX C (Tornado Analysis)



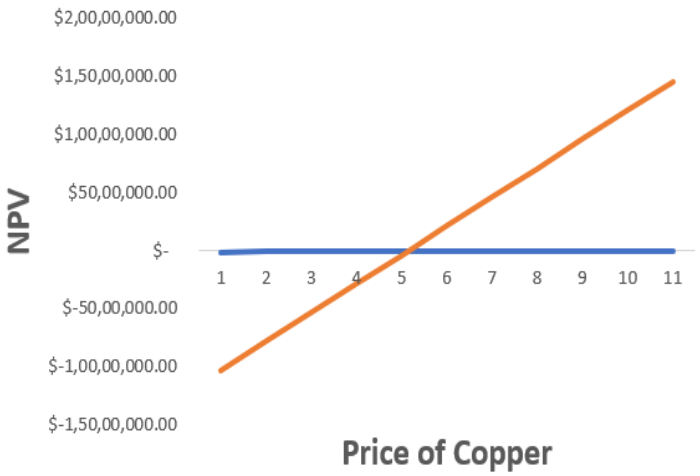
APPENDIX D.1 (One Way Sensitivity Analysis)

Change in Operating Cost of Copper	
NPV	
Operating Price	$ 70,93,416.17
$ 3,800.00	$ 2,44,92,361.48
$ 3,900.00	$ 2,20,06,797.86
$ 4,000.00	$ 1,95,21,234.25
$ 4,100.00	$ 1,70,35,670.63
$ 4,200.00	$ 1,45,50,107.01
$ 4,300.00	$ 1,20,64,543.40
$ 4,400.00	$ 95,78,979.78
$ 4,500.00	$ 70,93,416.17
$ 4,600.00	$ 46,07,852.55
$ 4,700.00	$ 21,22,288.93
$ 4,800.00	$ -3,63,274.68
$ 4,900.00	$ -28,48,838.30
$ 5,000.00	$ -53,34,401.91
$ 5,100.00	$ -78,19,965.53
$ 5,200.00	$ -1,03,05,529.15
$ 5,300.00	$ -1,27,91,092.76
$ 5,400.00	$ -1,52,76,656.38
$ 5,500.00	$ -1,77,62,219.99



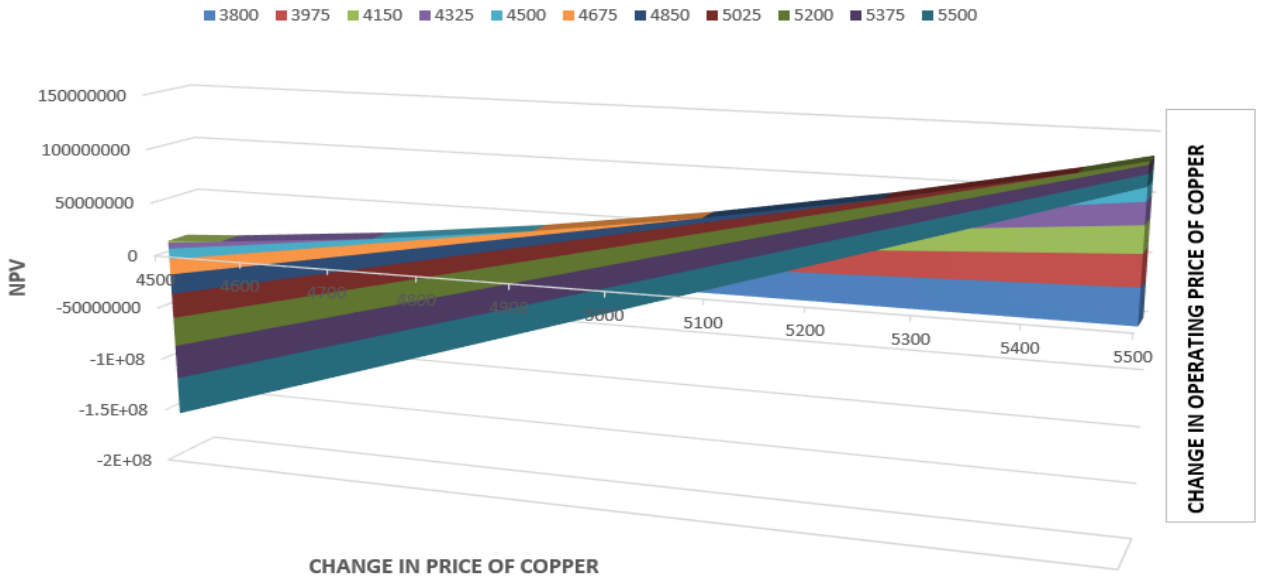
APPENDIX D.2 (One Way Sensitivity Analysis)

Effect on NPV with change in Price of Copper	
NPV	
Price of Copper	$70,93,416.17
$ 4,500.00	$-1,03,05,529.15
$ 4,600.00	$ -78,19,965.53
$ 4,700.00	$ -53,34,401.91
$ 4,800.00	$ -28,48,838.30
$ 4,900.00	$ -3,63,274.68
$ 5,000.00	$ 21,22,288.93
$ 5,100.00	$ 46,07,852.55
$ 5,200.00	$ 70,93,416.17
$ 5,300.00	$ 95,78,979.78
$ 5,400.00	$ 1,20,64,543.40
$ 5,500.00	$ 1,45,50,107.01

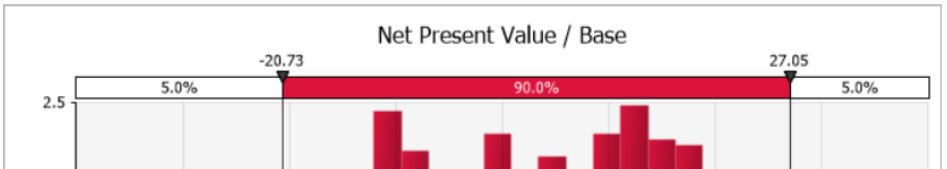


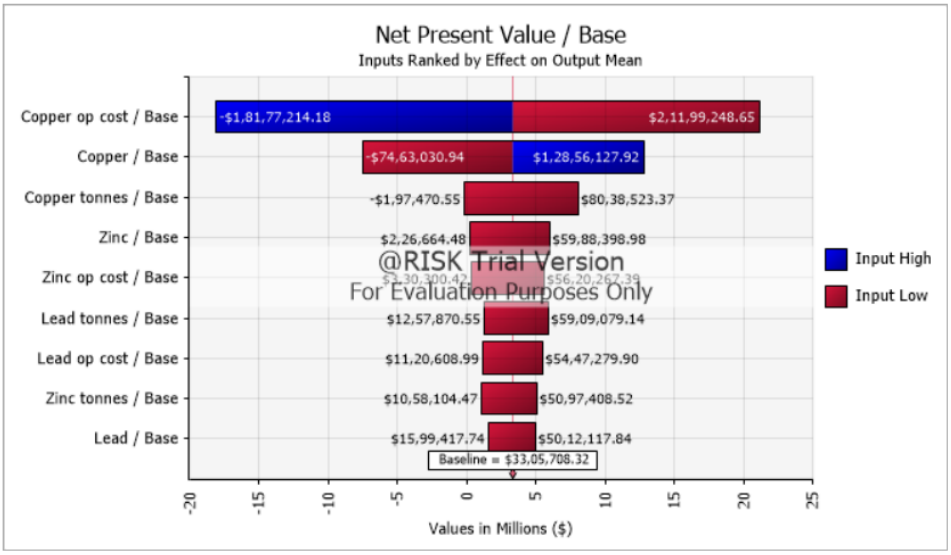
APPENDIX E (Two-Way Sensitivity Analysis)

Change in Price of Copper													
Change in Operating Cost	$70,93,416.17	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	5500
	3800	7093416.166	9578979.782	12064543.4	14550107.01	17035670.63	19521234.25	22006797.86	24492361.48	26977925.09	29463488.71	31949052.33
	3975	2743679.838	5229243.454	7714807.07	10200370.69	12685934.3	15171497.92	17657061.53	20142625.15	22628188.77	25113752.38	27599316
	4150	-1606056.49	879507.1257	3365070.742	5850634.358	8336197.974	10821761.59	13307325.21	15792888.82	18278452.44	20764016.05	23249579.67
	4325	-5955792.818	-3470229.202	-984665.5863	1500898.03	3986461.646	6472025.262	8957588.878	11443152.49	13928716.11	16414279.73	18899843.34
	4500	-10305529.15	-7819965.53	-5334401.914	-2848838.298	-363274.6823	2122288.934	4607852.55	7093416.166	9578979.782	12064543.4	14550107.01
	4675	-14655265.47	-12169701.86	-9684138.242	-7198574.626	-4713011.01	-2227447.394	258116.2217	2743679.838	5229243.454	7714807.07	10200370.69
	4850	-19005001.8	-16519438.19	-14033874.57	-11548310.95	-9062747.338	-6577183.722	-4091620.106	-1606056.49	879507.1257	3365070.742	5850634.358
	5025	-23354738.13	-20869174.51	-18383610.9	-15898047.28	-13412483.67	-10926920.05	-8441356.434	-5955792.818	-3470229.202	-984665.5863	1500898.03
	5200	-27704474.46	-25218910.84	-22733347.23	-20247783.61	-17762219.99	-15276656.38	-12791092.76	-10305529.15	-7819965.53	-5334401.914	-2848838.298
	5375	-32054210.79	-29568647.17	-27083083.55	-24597519.94	-22111956.32	-19626392.71	-17140829.09	-14655265.47	-12169701.86	-9684138.242	-7198574.626
	5500	-35161165.31	-32675601.69	-30190038.07	-27704474.46	-25218910.84	-22733347.23	-20247783.61	-17762219.99	-15276656.38	-12791092.76	-10305529.15



APPENDIX F (@Risk Simulation - 1)



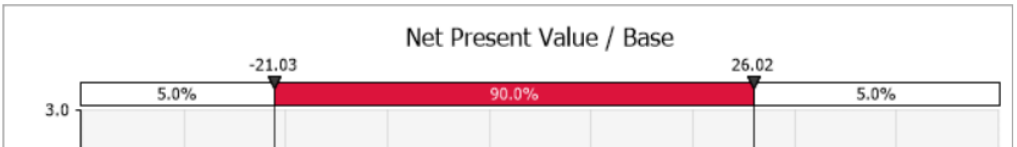


APPENDIX G.1 (@Risk Simulation with Correlation)

Summary Statistics

Output	Cell	Graphs	Function	Minimum	Maximum	Mean	Std Dev	5%	95%
Net Present Value / Base	Sheet1! C57		RiskOutput ("Net Present Value / Base")	-$3,14,47,625.15	$4,21,54,067.28	$33,17,397.60	$1,46,10,141.32	-$2,10,32,261.68	$2,60,22,595.09

APPENDIX G.2 (@Risk Simulation with Correlation)



APPENDIX H (@Risk Simulation with 7%-11% Discount Rate)

Statistics

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8	Sim 9	Sim 10
Cell	C57	C57	C57	C57	C57	C57	C57	C57	C57	C57
Minimum	-$4,35,24,05...	-$4,29,47,52...	-$4,23,83,06...	-$4,18,30,35...	-$4,12,89,086	-$4,07,58,941	-$4,05,91,59...	-$4,02,39,62...	-$3,97,30,86...	-$3,92,32,36...
Maximum	$3,92,01,723...	$3,86,82,444...	$3,81,74,043...	$3,76,76,225...	$3,71,88,705...	$3,67,11,208...	$3,65,60,482...	$3,62,43,468...	$3,57,85,226...	$3,53,36,233...
Mean	$34,39,567.37	$33,94,005.75	$33,49,398.50	$33,05,719.81	$32,62,944.72	$32,21,049.05	$32,07,824.33	$31,80,009.42	$31,39,803.20	$31,00,408.45
90% CI	± $8,29,530....	± $8,18,542....	± $8,07,784....	± $7,97,250....	± $7,86,933....	± $7,76,829....	± $7,73,640....	± $7,66,932....	± $7,57,235....	± $7,47,734.64
Mode	$53,54,577.53	$52,83,649.07	$52,14,206.33	$51,46,209.14	$50,79,618.62	$50,14,397.16	$49,93,809.46	$49,50,508.35	$48,87,916.95	$48,26,588.82
Median	$47,46,482.11	$46,83,608.69	$46,22,052.25	$45,61,777.19	$45,02,749.06	$44,44,934.51	$44,26,684.86	$43,88,301.27	$43,32,818.09	$42,78,454.72
Std Dev	$1,59,33,186...	$1,57,22,130...	$1,55,15,495...	$1,53,13,161...	$1,51,15,013...	$1,49,20,939	$1,48,59,677...	$1,47,30,830...	$1,45,44,582	$1,43,62,092...
Skewness	-0.1202	-0.1202	-0.1202	-0.1202	-0.1202	-0.1202	-0.1202	-0.1202	-0.1202	-0.1202
Kurtosis	2.1376	2.1376	2.1376	2.1376	2.1376	2.1376	2.1376	2.1376	2.1376	2.1376