Portfolio Cost Scenario Analysis

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This report is a summary of portfolio cost scenario analyses when (1) hedging instruments are applied and (2) stress testing is performed. The attached Matlab code is for generating distributions of unhedged portfolios only.

- A total of 10,000 Monte Carlo simulations were implemented based on a two factor stochastic model without a drift. Two random numbers were applied to long and short-term volatilities, respectively.
- Portfolio cost distributions were generated based on weighted average prices.
- 12-month-forward prices in the energy market were used from Jan to Dec 2018 by assuming a one-dollar incremental for each month. (Average price as of today: $45.45)
- For simplicity, the forward prices (12 by 1) of the first market were used, rather than multiples.
- The numbers 42 and 50 were randomly chosen to demonstrate changes of probabilities.
- Hypothetical stress testing was conducted by shocking risk factors (forward price and volatility).

1. Portfolio Cost Scenario Analysis by Hedging Instruments

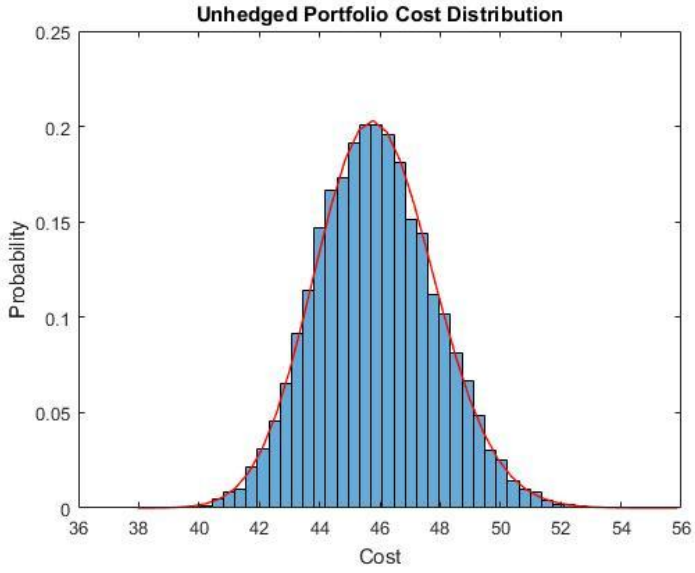

Figure 1. Portfolio Distribution – Unhedged Portfolio

Unhedged Portfolio			
mean	45.5484	**P(x < 42)**	17.39%
std	3.7794	**P(x > 50)**	12.20%

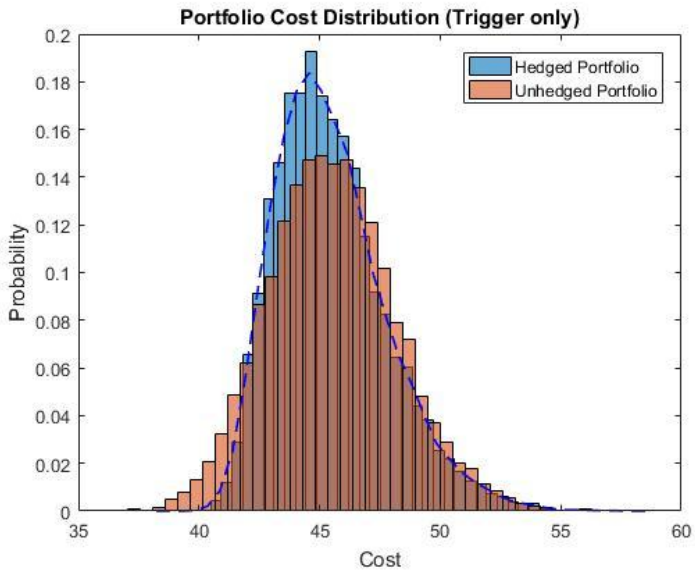

Figure 2. Portfolio Distribution – Trigger was applied to reduce a downside risk

Unhedged Portfolio			
mean	45.4960	**P(x < 42)**	18.01%
std	3.8216	**P(x > 50)**	12.05%
Hedged Portfolio			
mean	45.4616	**P(x < 42)**	12.40%
std	3.2323	**P(x > 50)**	9.54%

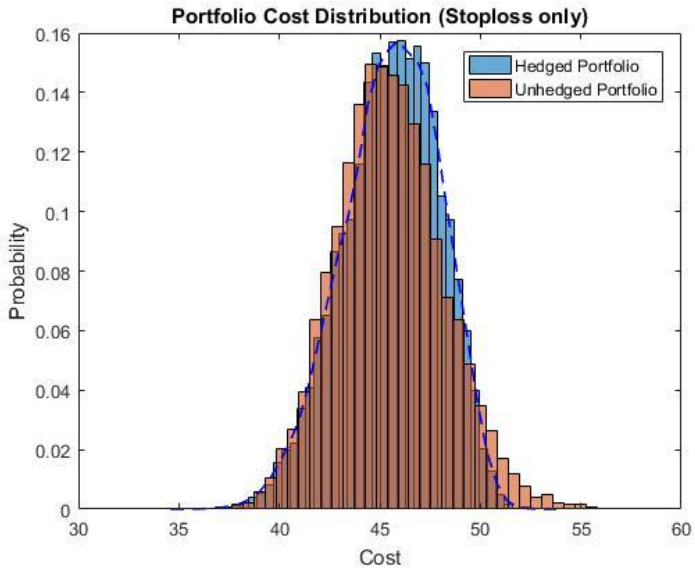

Figure 3. Portfolio Distribution – Stop loss was applied to reduce an upside risk

Unhedged Portfolio			
mean	45.4464	**P(x < 42)**	17.85%
std	3.7820	**P(x > 50)**	11.58%
Hedged Portfolio			
mean	45.5398	**P(x < 42)**	16.10%
std	3.3753	**P(x > 50)**	8.98%

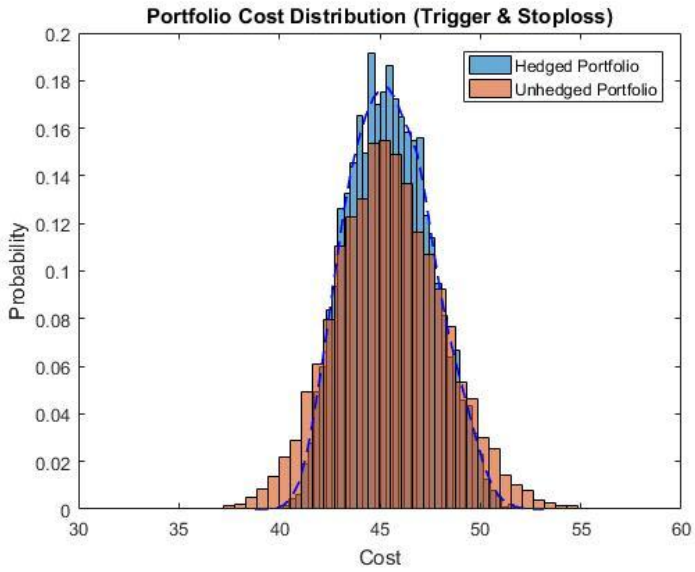

Figure 4. Portfolio Distribution – Trigger and stop loss were applied to reduce both downside/upside risks

Unhedged Portfolio			
mean	45.4766	**P(x < 42)**	18.37%
std	3.7905	**P(x > 50)**	11.77%
Hedged Portfolio			
mean	45.4992	**P(x < 42)**	11.53%
std	2.7834	**P(x > 50)**	6.52%

2. Portfolio Cost Scenario Analysis by Hypothetical Stress Testing

1) Forward Prices, (+/- 10%)

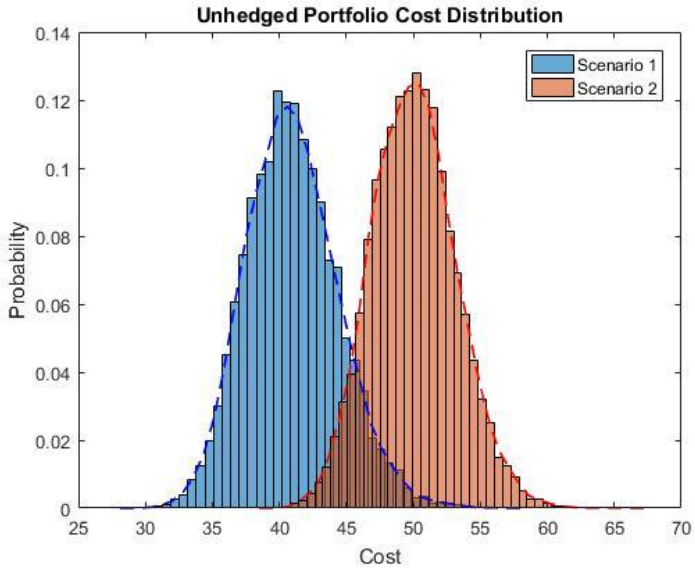

Figure 5. Portfolio Distribution – Forward Prices, (+/- 10%)

Unhedged Portfolio - Scenario 1 (-10%)			
mean	40.9415	**P(x < 42)**	63.85%
std	3.3927	**P(x > 50)**	0.77%
Unhedged Portfolio - Scenario 2 (+10%)			
mean	50.0463	**P(x < 42)**	0.21%
std	3.1036	**P(x > 50)**	49.53%

2) Long and Short-Term Volatilities, (+/- 10%)

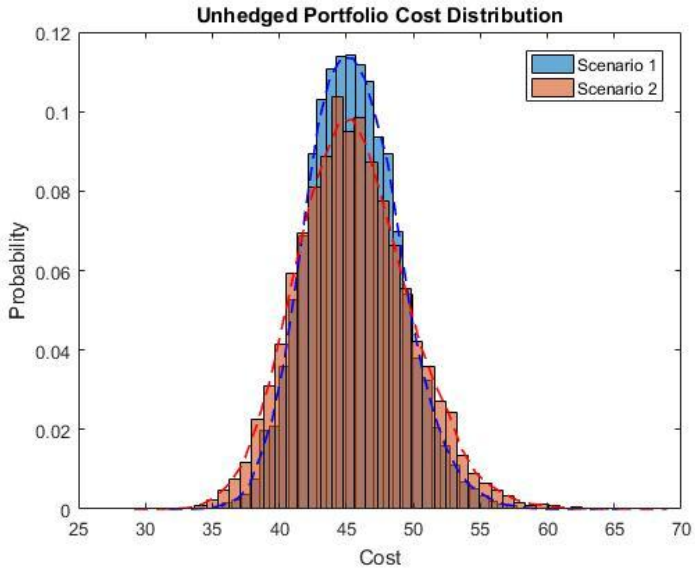

Figure 6. Portfolio Distribution - Long and Short-Term Volatilities, (+/- 10%)

Unhedged Portfolio - Scenario 1 (-10%)			
mean	45.5393	**P(x < 42)**	14.32%
std	3.3596	**P(x > 50)**	9.34%
Unhedged Portfolio - Scenario 2 (+10%)			
mean	45.5228	**P(x < 42)**	19.70%
std	4.1175	**P(x > 50)**	13.93%

3. Summary

Figures 2-4 illustrate that Monte Carlo simulations were well utilized, given that the means of the hedged portfolio distributions were approximately equal to the average value of the forward prices as of today. (Again, we assumed the risk neutral world in the beginning.) In addition, the hedging instruments, trigger and stop loss, were seen to effectively mitigate the portfolio's downside and upside risks. For the next step, the sobol sequence random numbers and variance reduction techniques could be redeemed to increase the accuracy of the simulation results.

The stress testing, as demonstrated in Figures 5 and 6, was applied to unhedged portfolios only. Additionally, the testing could be expanded on portfolios with hedging instruments. We may also consider drastic changes of macroeconomic factors (such as interest rate and currency) or an unusually strong correlation among assets in a portfolio for further risk factors.