This Week

Monday

- Recap: Project Risk Analysis

Wednesday

- Lab Exercise: Trend Estimation
  for Existing Liquair-Pro Customers

Topics

- Risk and Uncertainty
- Risk Analysis Methods
- Choosing the “Best” Alternative

A Problem Solving Framework

1. *Define the Problem*
2. *Collect and Organize Data*
3. *Characterize Uncertainty and Data Relationships*
4. *Build an Evaluation Model*
5. *Formulate a Solution Approach*
6. *Evaluate Potential Solutions*
7. *Recommend a Course of Action*

Risk And Uncertainty

In the context of projects:

- ***Uncertainty*** exists when the value of one or more parameters affecting a project's economic and/or operating characteristics are *unknown*.

- ***Risk*** is the *potential for loss* arising from uncertainty.

- The goal of ***risk analysis*** is to identify the *magnitude and likelihood of potential loss* associated with various decision alternatives.

Recall: Decision Making With Well-Defined Outcomes

Given:

- The set of ***decision alternatives***
- The possible ***outcomes*** of the sources of uncertainty
- The associated ***probabilities*** of each outcome

We need to determine:

- What are the ***consequences*** for each possible combination of decision alternative and outcome?
- How should we ***measure*** the decision alternatives?
- What is the ***best*** decision alternative?

Can we apply this framework to Liquair-Pro?

Risk Analysis Methods

- **Sensitivity Analysis**
- **Break-Even Analysis**
- **Scenario Analysis**
- **Probabilistic Risk Analysis**

Sensitivity Analysis

- Measures how variations in individual parameters (usually one or two) affect a project's NPW.
  - \+ **Good for determining which individual factors impact the NPW most profoundly.**
  - – ***Does not evaluate the likelihood*** **of realizing specific parameter values.**
  - – **May not provide a good assessment of realistic outcomes since** ***interactions among variables are ignored*****.**

Break-Even Analysis

- For a particular parameter, determines the value that makes the decision-maker indifferent to accepting or rejecting a project.
  + **Good for determining the individual parameter levels at which "good" projects become "bad" projects.**
  - ***Does not evaluate the likelihood*** **of realizing specific parameter values.**
  - **May not provide a good assessment of realistic outcomes since** ***interactions among variables are ignored*****.**

Scenario Analysis

- Evaluates and compares several possible collections of parameters that are representative in some meaningful way (e.g., base case, worst case, best case scenarios)
  - \+ **Provides an assessment of a subset of realistic outcomes, variable interactions captured within the scenario.**
  - – ***Does not evaluate the likelihood*** **of realizing the evaluated scenarios or intermediate scenarios.**

Probabilistic Risk Analysis

- Uses individual or joint probability distributions for key uncertain parameters to determine a probability distribution for the project's NPW.
  - \+ **Takes into account the likelihood of realizing specific parameter values**
  - – ***Must establish these likelihoods***
  - – ***Can become very complicated*** **as the number of uncertain parameters (and/or the number of possible values) increases. Independence is frequently assumed for tractability.**

Dealing With Scale

- Suppose that a project has ***2 unknown parameters*** and ***each parameter has 30 possible values***. How do we analyze 2^{30} > 1 billion scenarios?

- A ***Monte Carlo Simulation*** approach:

1. ***Define probability distributions*** for each unknown parameter (and/or joint distributions for each group of dependent unknown parameters).

2. ***Generate random values*** for each unknown parameter according to their respective distributions and compute the resulting cash flows and NPW. Repeat this many times.

3. ***Use the realizations to establish an approximate probability distribution for the NPW*** and other metrics of interest that may affect the project decision.

Monte Carlo Simulation

- How does ***tank size = LA-1*** and ***price/Kgallons = $594.132*** perform if the two primary sources of uncertainty are projected demand and annual growth rate?

Factor 1** = Projected Year 1 Demand				
Mean:	130,000	from Price Quote sheet	Standard Deviation:	5,000

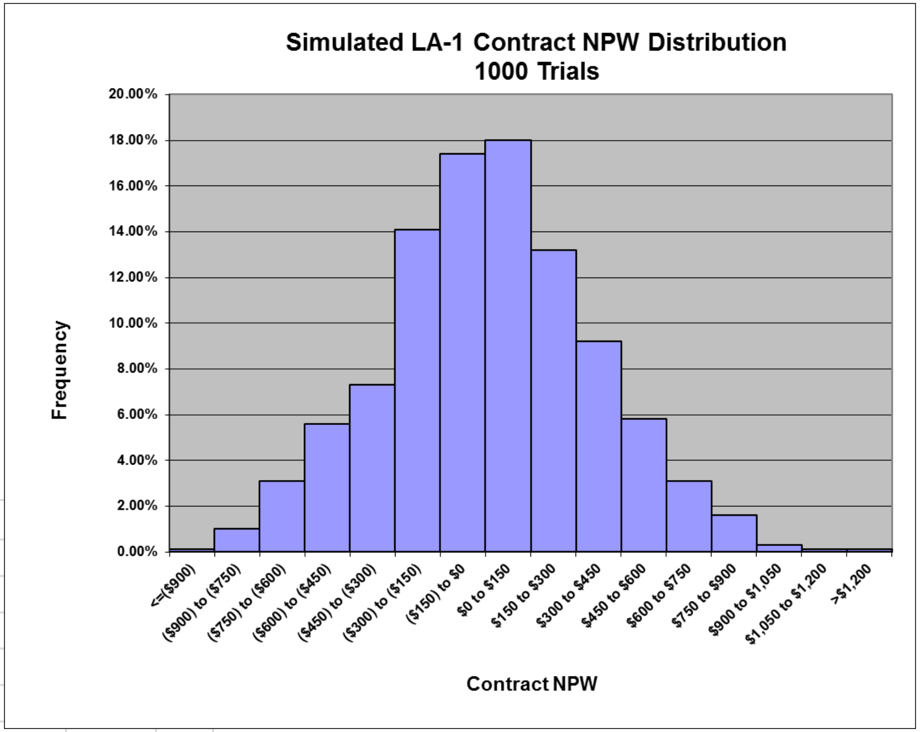
Factor 2** = Projected Annual Growth Rate				
Mean:	5.00%	from Price Quote sheet	Standard Deviation:	0.50%

Example Statistical Results

	LA-1
Price per KGallons for Simulation:	$594.132

	Contract NPW
Average:	$16.39
Std Dev:	$347.25

Contract NPW Range	Frequency	As %	Cumulative %	
<=($900)	1	0.10%	0.10%	
($900) to ($750)	10	1.00%	1.10%	
($750) to ($600)	31	3.10%	4.20%	
($600) to ($450)	56	5.60%	9.80%	
($450) to ($300)	73	7.30%	17.10%	
($300) to ($150)	141	14.10%	31.20%	
($150) to $0	174	17.40%	48.60%	<== Loss Probability
$0 to $150	180	18.00%	66.60%	
$150 to $300	132	13.20%	79.80%	
$300 to $450	92	9.20%	89.00%	
$450 to $600	58	5.80%	94.80%	
$600 to $750	31	3.10%	97.90%	
$750 to $900	16	1.60%	99.50%	
$900 to $1,050	3	0.30%	99.80%	
$1,050 to $1,200	1	0.10%	99.90%	
>$1,200	1	0.10%	100.00%	
	1000	100.00%		



Choosing the "Best" Alternative

Questions to Consider:

- ***How should this tank/price combination be compared against other alternatives?***
- ***What other information should be captured for each simulation trial besides the Contract NPW?***
- ***If parameter likelihoods cannot be established with accuracy, what other methods can be employed to hedge against uncertainty?***

Risk Analysis Lab Exercise

Given:

- A ***tank size*** **for a customer**
- **Estimates for the** ***average*** **and** ***standard deviation*** **of the customer's** ***Year 1 demand***
- **Estimates for the** ***average*** **and** ***standard deviation*** **of the customer's** ***annual demand growth rate***
- **A** ***target loss probability*** **with a** ***tolerance window***

Goal:

Determine the price per K-Gallon that corresponds to the target loss probability (within the tolerance window).

Example: Bisection Search Algorithm