Agribusiness Analysis and Forecasting

Scenarios & Sensitivity Analysis

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Using a Simulation Model

Assume we have a working simulation model.

Model has the following parts.

- Input section where the user enters all input values that are management control variables
- Area where parameters are organized
- Stochastic variables
- Equations to calculate intermediate variables.
- Equations to calculate final output variables.

We are ready to run scenarios on control variables and make recommendations.

What are Scenarios?

- One key reason to build simulation models is to test the impacts of alternative management or policy options.
- Each alternative management or policy option is a scenario.
- Care must be taken to insure that all values, including the risk, in the model are identical from one scenario to the next.
- If we use different risk (underlying standard uniform draws) across scenarios then the results are not comparable.
- Distributions of final output variables should reflect changes in management variables and nothing else

Simulating Scenarios with Simetar

- Simetar includes functions to simulate multiple scenarios.
- The functions guarantee that the random variables have the same underlying standard uniform values from across scenarios
- User must provide values for all variables that define the alternative scenarios using

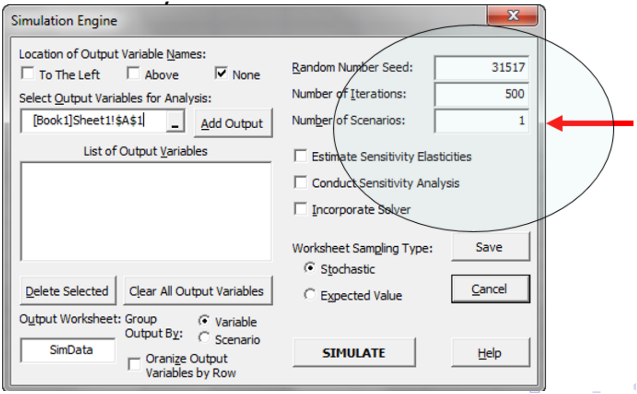
$$= SCENARIO(alt1, alt2, alt3, \ldots, altN)$$

- The model can have as many scenarios as needed

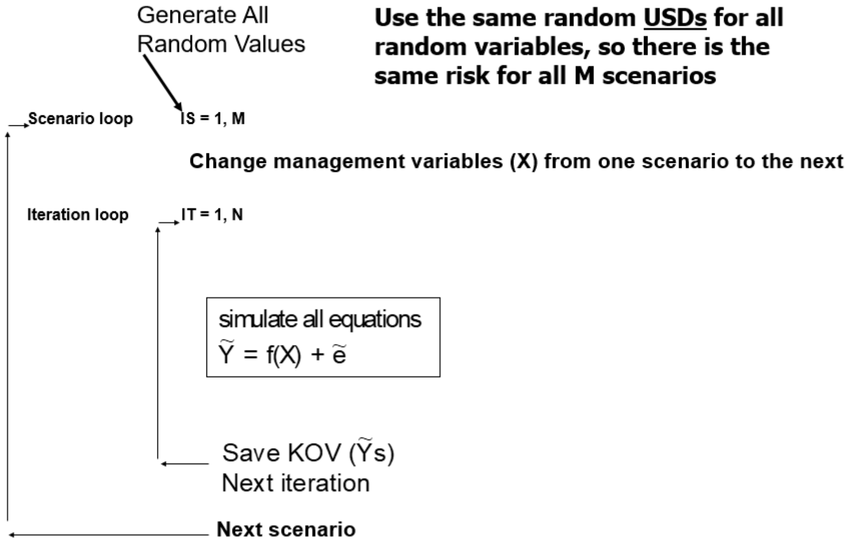
Specifying the Number of Scenarios

Simetar simulation engine controls:

- Number of scenarios.
- Sensitivity analysis.
- Sensitivity elasticities.



Flow Chart for Scenario Analysis



Example of a Scenario Table

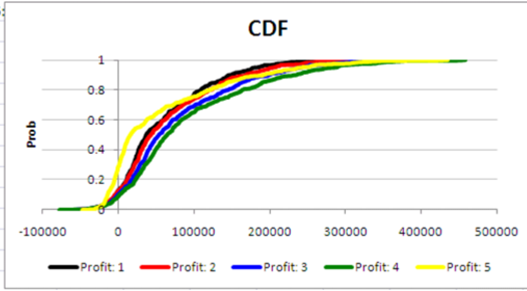
Example of 5 Scenarios for the risk and variable costs:

	A	B	C	D	E	F	G	H
4	Calcualte Profit for 5 Scenarios							
5	Production	Scenario		Scen 1	Scen 2	Scen 3	Scen 4	Scen 5
6	Mean	12,000	=SCENARIO(D6:H6)	12000	13000	15000	17000	18000
7	Std Dev	1,200	=SCENARIO(D7:H7)	1200	2400	3000	4000	5000
8	Stochastic Price	13,167	=NORM(B6,B7)					
9								
10	Price							
11	Min	25	=SCENARIO(D11:H11)	25	25	20	20	18
12	Middle	30	=SCENARIO(D12:H12)	30	30	25	25	20
13	Max	45	=SCENARIO(D13:H13)	45	45	40	40	35
14	Stochastic Price	35	=GRKS(B11,B12,B13)					
15								
16	Fixed Costs	25,000						
17								
18	Varaible Cost/Unit	25	=SCENARIO(D18:H18)	25	25	20	20	18
19								
20	Total Receipts	456,443	=B8*B14					
21	FC	25,000	=B16					
22	VC	329,174	=B18*B8					
23	Profit	102,269	=B20-B21-B22					

Results of the Scenario Analysis

Scenarios are numbered in SimData for ease of graphing and comparison of statistics.

Simetar Simulation Results for 5 Scenarios, 500 Iterations. 10:15:					
Variable	Sheet1!B2	Sheet1!B2	Sheet1!B2	Sheet1!B2	Sheet1!B23
Mean	58560.23	65177.36	78978.17	92653.08	56277.48
StDev	62541.54	69227.96	80369.48	92590.11	87088.77
CV	106.7987	106.2147	101.7616	99.93203	154.7489
Min	-60463.6	-65043.7	-71545.1	-78637.4	-48168.9
Max	274245.3	327568	387764.3	458282.6	435130.6
Iteration	Profit: 1	Profit: 2	Profit: 3	Profit: 4	Profit: 5
1	25658.43	18670.95	23038.01	23329.07	-6453.5
2	14984.04	13813.56	18840.3	22229.78	-6248.83
3	51555.74	56185.76	68308.82	79795.66	34392.61
4	102161.7	108508.4	128156.5	146259.1	104655.4
5	175964.2	192192.1	225497.4	258613.9	221357.7
6	75718.86	69382.3	80812.49	86886.38	49866.53



Sensitivity Analysis

Sensitivity analysis used to determine how sensitive the output variables are to changes in one parameter or variable at a time. For example:

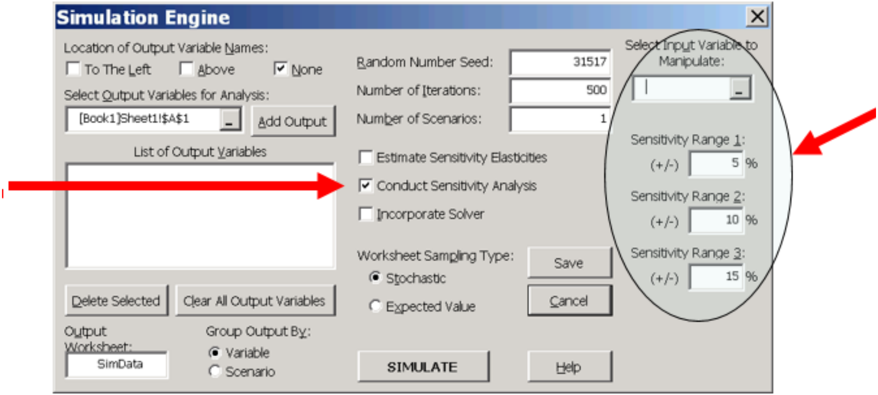
- Does net return change a little or a lot when you change variable X by 10%?
- Does NPV change greatly if the assumed fixed cost changes by 10%?

Simulates the model 7 times changing the “change” variable for each simulation.

Like scenario analysis, Simetar has a sensitivity option that insures the same random values used for each run.

Sensitivity Analysis

- Specify as many KOVs as you want.
- Specify only ONE sensitivity variable.
- Simulate the model and 7 sensitivities are run.



Demonstrate Sensitivity Simulation

Change the Price per unit by these percentages:

- + or – 5%
- + or – 10%
- + or – 15%

Simulates the model 7 times:

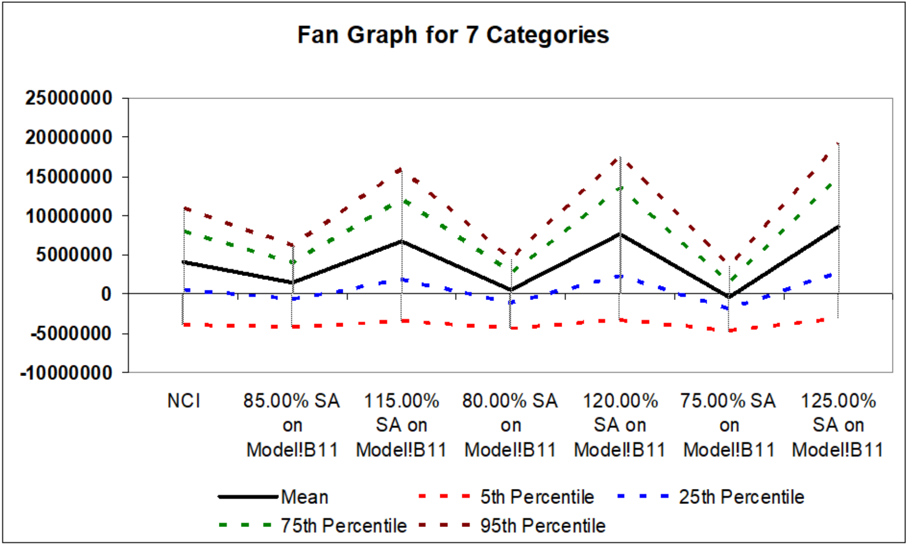
- The initial value specified in the change cell.
- Two runs for + and – 5% for the control variable.
- Two runs for + and – 10% for the control variable.
- Two runs for + and – 15% for the control variable.

Sensitivity Results

- Test the sensitivity of price received for the product on Net Cash Income.
- Note that we get 7 sets of results in SimData; base plus six.
- Labels indicate the % difference from the initial value of the change variable.

	A	B	C	D	E	F	G	H
1	Simetar Simulation Results for 500 Iterations.							
2	Variable	Model!B50	Model!B50	Model!B50	Model!B50	Model!B50	Model!B50	Model!B50
3	Mean	4,359,704	1,641,859	7,077,549	735,911	7,983,497	(170,037)	8,889,445
4	StDev	4,818,880	3,499,541	6,256,265	3,112,439	6,748,779	2,770,766	7,245,728
5	CV	111	213	88	423	85	(1,630)	82
6	Min	(6,805,331)	(7,530,597)	(6,161,688)	(7,772,352)	(6,077,965)	(8,014,107)	(6,071,014)
7	Max	16,213,694	10,758,714	21,668,673	8,940,388	23,486,999	7,122,062	25,305,326
8	Iteration	NCI	85.00% SA on M	115.00% SA on M	80.00% SA on M	120.00% SA on	75.00% SA on M	125.00% SA on M

Display Sensitivity Results in a Chart



Sensitivity Elasticities (SE)

- Sensitivity of **one** output variable with respect to multiple values in the model can be estimated and displayed in terms of elasticities, calculated as:

$$SE_j = \frac{\%\Delta\text{output variable}}{\%\Delta\text{value}_j}$$

- Calculate SE's for an output variable wrt. the change var_j for each iteration, then calculate the mean and standard deviation of the SE
- SE's can be calculated for small changes in parameters or control variables, say, 1%

Interlude: Value types

Nominal	Just names, IDs
Ordinal	Have / represent rank order (e.g. fully agree, mostly agree, somewhat agree)
Interval	Has a fixed size of interval between data points. (E.g. degrees Centigrade)
Ratio	Has a true zero point (e.g. mass, length, degrees Kelvin)

- http://www.psy.gla.ac.uk/~steve/best/ordinal.html
- https://en.wikipedia.org/wiki/Level_of_measurement

Interlude: Value types

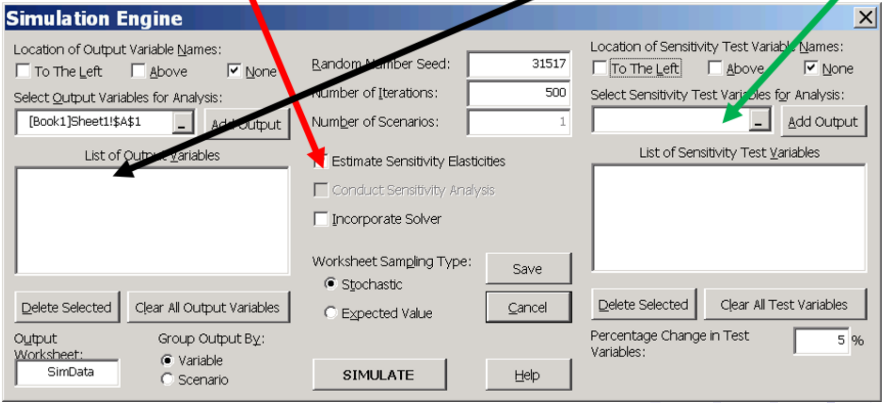
Incremental progress	Measure property	Mathematical operators	Advanced operations	Central tendency
Nominal	Classification, membership	$=, \neq$	Grouping	Mode
Ordinal	Comparison, level	$>, <$	Sorting	Median
Interval	Difference, affinity	$+, -$	Yardstick	Mean, Deviation
Ratio	Magnitude, amount	$\times, /$	Ratio	Geometric mean, Coefficient of variation

Interlude: Value types

- Be careful what types of values you specify for calculating elasticities.
- **Percentage change is a ratio/division operation**. This should be a valid operation for the type of value you are considering.
- These operations should be reserved for *ratio* values, and are not valid for *interval* values.
- For example, the idea of percentage change in profit does not make sense, given that profit may be negative. Profit is an interval value, not a ratio value.
- Simetar will **silently** calculate non-sensical sensitivity elasticities if you apply this feature to non-ratio values.

Activating Sensitivity Elasticities

- Turn on the SE option by clicking on the Estimate Sensitivity Elasticities tab
- Specify the Single KOV in List of Output Variables
- Specify change variables in the List of Sensitivity Test Variables



Ranking Risky Scenarios

- Once a model can simulate multiple scenarios, the question becomes "which is the best scenario?"
- How to answer this question is a key issue in microeconomics.
- There are many different methods, with varying degrees of complexity and theoretical attractiveness.
- We will present and evaluate several methods.

Ranking Risky Alternatives

Simulation results can be presented many different ways to help the decision makers (DM) make the best decision for themselves.

- Tables of summary statistics
- Probabilities for different values for output variables
- PDFs and CDFs.
- StopLight charts.
- Fan graphs.
- others

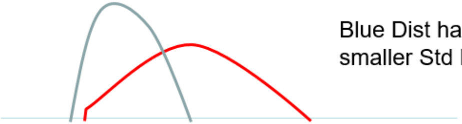
Purpose here is to present some helpful methods for ranking risky alternatives ro facilitate decision making

Decision Making for Risky Alternatives

- Decision makers rank risky alternatives based on their utility for income and the risk aversion reflected in their utility function.
- Several of the ranking procedures ignore utility, but they are easy to use.
- The more complex procedures incorporate utility but can be complicated to use.

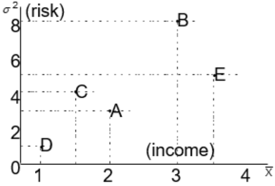
Easy to Use Ranking Procedures

- **Mean only** – Pick scenario with the highest mean – **ignores all risk**
- **Minimize Risk** – Pick the scenario with lowest Std Dev – this ranking strategy **ignores the level of returns** (mean and relative risk)



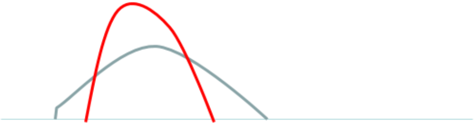
Blue Dist has the smaller Std Dev!

- **Mean Variance** – Always select the scenario in lower right quadrant **often difficult to read and often results in tied rankings**, does not work well for non-normal distributions.
  - In the diagram below A is preferred to C; E is preferred to B
  - Indifferent between A and E

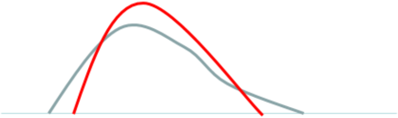


Easy to Use Ranking Procedures

- **Worst case** – Bases decisions on scenario with highest minimum, but it was observed with less than a 1% chance. Worst case had a 1 out of 500 chance of being observed -- has merit in that it avoids catastrophic losses, **but ignores the level of returns and ignores upside risk**.



- **Best case** –Looks at only one iteration, the best, which has < 1% chance. Best case had a 1 out of 500 chance of being observed -- **ignores the overall risk and downside potential risk**.



Easy to Use Ranking Procedures

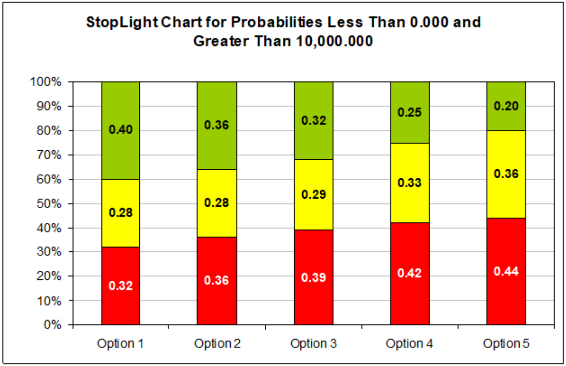
Relative risk - Coefficient of Variation (CV), pick the scenario that has lowest CV. Easy to use, considers risk relative to the expected value, but ignores the decision maker's risk aversion and **is only valid for ratio values** (so, for example, not valid for profit)

$$CV = \frac{Std.Dev}{Mean} * 100$$

Iteration	Option 1	Option 2	Option 3	Option 4	Option 5
Mean	5948.63	4894.94	3277.08	1642.44	-92.55
StDev	13012.63	14130.17	13615.85	13697.44	14419.89
CV	218.75	288.67	415.49	833.97	-15579.92
Min	-33653.55	-38159.43	-38331.16	-40112.24	-43798.94
Max	39572.48	41537.27	38627.14	37145.60	37376.81

Easy Ranking Procedures

Stoplight Chart – Calculate and report the probability of achieving a preferred target and probability of failing to achieve a minimum target, i.e., the StopLight chart. This method is easy to use and easy to present to decision makers who do not understand risk.



Easy Ranking Procedures

Rank Scenarios Based on Complete Distribution - Graph the distributions as CDFs and compare the relative risk of the returns for each distribution at alternative levels of return. Pick the distribution with the highest return at each risk level or pick the distribution with the lowest risk for each level of returns, i.e., the distribution furthest to the right.