Simulation and Risk Analysis

Using Analytic Solver Platform

REVIEW BASED ON MANAGEMENT SCIENCE
What We’ll Cover Today

• Introduction
  • Frontline Systems
  • Session I Beta Training Program Goals
  • Overview of Analytic Solver Platform (ASP)

• Model Building
  • Sensitivity Analysis
  • Distribution Wizard
  • Correlation
  • Parametric Simulation

• Decision Tree
Frontline Systems Inc.

- Software Products for:
  - Conventional and Stochastic Optimization
  - Simulation/Risk Analysis
  - Data Mining and Visualization
- 26 Years in Business (Founded 1988)
- 7,000 Companies as Customers:
  - Commercial
  - Academic
  - Software vendors
- 500,000 Users
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Frontline Systems Consulting Lead and Modeling Specialist. 

Experience – Network design, supply chain simulation and optimization, facility location, 3D layout optimization, scheduling, and "lean healthcare" resource utilization.
Session I Online Beta Training Goals

To familiarize you with the following concepts:

- Building Monte Carlo simulation models in Excel using ASP
- Using sensitivity analysis (Parameters-Identify)
- Using historical data to fit a distribution
- Applying parametric simulation technique
- Using decision trees in decision analysis

To empower you to achieve success

- State of the art tools
- Online educational training
- User guides and video demos
Business Analytics Techniques

- **Descriptive Analytics**
  - Analyze what has happened
  - Business intelligence queries/reports
  - Data visualization
  - Data transformation

- **Predictive Analytics**
  - Use data to segment or classify customers
  - Use data to predict future behavior
  - Data mining
  - Forecasting

- **Prescriptive Analytics**
  - Determine the best course of action to take
  - Optimization
  - Simulation
  - Decision analysis
Why Use Risk Analysis?

• Almost every business outcome has some uncertainty.
• “Expected case” or “average” estimates are typically wrong when there is uncertainty.
• What-if analysis is insufficient when you have multiple uncertain factors.
• Quickly quantify the full range of possible outcomes.
• Graphically show management / stakeholders the range of outcomes.
• Risk analysis skills are a career enhancer.
  • Know what factors really matter.
  • Give yourself a competitive advantage.
  • Be better prepared for executive decisions.
What is Monte Carlo Simulation?

• A flexible technique for modeling a real system in which uncertainty is a key factor.
  • Uses repeated random sampling to represent uncertainty.

• With appropriate sampling, outputs are representative of results from all possible combinations of uncertain inputs.

• For a given decision (values of inputs under your control), simulation describes the outcomes and the probabilities that these outcomes will occur.

• Analytic Solver Platform helps you perform Monte Carlo simulation in spreadsheet models.
To apply the Monte Carlo method, you can construct a mathematical model that simulates a real situation.

1. Construct a what-if spreadsheet model.
2. Identify uncertain inputs & specify probability distributions.
3. Select outputs to record over the simulation trials.
4. Execute simulation for a number of trials.
5. Analyze the outputs.
Frontline Solvers
Risk Analysis Software

Monte Carlo Simulation & Decision Trees

Stochastic & Robust Optimization

Risk Solver Platform & Analytic Solver Platform

Risk Solver Pro
Brief Overview of Analytic Solver Platform (ASP)

Ribbon
Gateway to Analytic Solver Platform’s graphical user interface.

- **Model**: to display the Task Pane, defining dimensional models.
- **Optimization Model**: to set up optimization models.
- **Simulation Model**: to set up simulation models.
- **Parameter**: to run multiple optimizations or simulations.
- **Solve Action**: to solve optimization or simulation model.
- **Analysis**: to analyze the results, create reports and charts.
Brief Overview of Analytic Solver Platform (ASP)

Ribbon

- **Tools:** to create decision trees, fit distributions, examine simulation or optimization results.
- **Options:** to set options for optimization, simulation, charts and graphs.
- **Help:** to display online Help, use Live Chat, control Guided Mode, open examples or an online tutorial, access User and Reference Guides, and check the license status.
Brief Overview of ASP

**Task Pane**

- **Model button**: to display or hide the Task Pane.
- **Model tab**: to view the model in outline form and optionally edit model elements in place.
- **Platform tab**: to view or change Platform options.
- **Engine tab**: to select simulation options for Risk Solver Engine.
- **Output tab**: to view a log of simulation messages.
Example – Corporate Valuation

- Netscape Communications – Powell and Baker, page 375.
- How simulation can be applied to the valuation of company?
- Underwriter’s valuation – offer five million shares at $28 per share, raising $140 million.
  - Annual revenue growth 65%.
  - Terminal-value growth 4%, calculated under the assumption that the free cash flows after 2005 would grow forever at a constant rate.
  - Tax rate 34%.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue growth rate</td>
<td>65%</td>
</tr>
<tr>
<td>Terminal value growth rate</td>
<td>4.00%</td>
</tr>
<tr>
<td>Cost of sales (% revenues)</td>
<td>10.40%</td>
</tr>
<tr>
<td>R&amp;D (% revenues)</td>
<td>36.80%</td>
</tr>
<tr>
<td>Tax rate</td>
<td>34.00%</td>
</tr>
<tr>
<td>Other operating expenses</td>
<td></td>
</tr>
<tr>
<td>Capital expenditure</td>
<td></td>
</tr>
<tr>
<td>Depreciation (% revenues)</td>
<td>5.50%</td>
</tr>
<tr>
<td>ΔNWC</td>
<td>0.00%</td>
</tr>
<tr>
<td>Beta</td>
<td>1.50</td>
</tr>
<tr>
<td>Riskless rate</td>
<td>6.71%</td>
</tr>
<tr>
<td>Market risk premium</td>
<td>7.50%</td>
</tr>
<tr>
<td>Cost of equity</td>
<td>17.96%</td>
</tr>
<tr>
<td>Shares outstanding</td>
<td>38,000</td>
</tr>
</tbody>
</table>
Example – Corporate Valuation Sensitivity Analysis

• Before incorporating uncertainty, undertake some sensitivity analysis.

• How sensitive the terminal value (cell B36) is to the driving variables.
  • Terminal-value growth rate and market risk premium.
  • Terminal value makes up 77% of total present value.

• Create a Tornado chart to evaluate which parameters most affect the valuation.

• Select Cell B37, Total PV, then choose Parameters – Identify from the Ribbon.
Summary – Sensitivity Analysis Report

• Define an input cell as a parameter by simply selecting the cell, choosing Parameters and Sensitivity from the Ribbon.

• Enter a lower and upper limit on values for the parameter, or a list of explicit values for the parameter.

• Choose Reports – Sensitivity – Parameter Analysis from the Ribbon.

• Use the arrow buttons select one or more result cells (exactly one if you check the box “Vary Parameters Independently”).

• Use the arrow buttons to select one or more sensitivity parameter cells (exactly two if you check the box “Vary Parameters Independently”).

• Then click OK to produce the report.
Example – Corporate Valuation
Selecting Probability Distributions

• How does the uncertainty in these parameters affect the valuation of Netscape?
• Was the IPO valuation justified in light of these uncertainties?
  • Revenue growth rate: Normal, with a mean of 65 percent and a standard deviation of 5 percent.
  • R&D as a percentage of revenues: Triangular, with a minimum of 32 percent, most likely value of 37 percent, and a maximum of 42 percent.
  • Market-risk premium: Uniform, with a minimum of 5 percent and a maximum of 10 percent.
Example – Corporate Valuation
Selecting Probability Distributions

• Distribution of Total Value for Netscape

• Ratio of Terminal Value to Total Value

• Stock Price
Summary of Steps – Selecting Probability Distributions

- Choose a currently empty cell, then select **Distributions - Discrete** on the Ribbon.
- Choose your desired discrete distribution from the gallery.
- Enter the appropriate parameters.
- Click on the Save and Close icon.
Summary of Steps – Specifying Statistics and Outputs

- Choose your desired formula cell, then select **Results – Statistics** from the Ribbon.
- Drag and drop a statistics functions, into a worksheet cell.
- To designate a cell as an uncertain function without calculating any summary statistic for it on the worksheet, highlight the cell, then select **Results – Output – In Cell**.
Example – Corporate Valuation
What-If with Interactive Simulation

• Question: how our simulation estimates would vary if one of the underlying parameters were to change.
  • How sensitive the expected NPV is to the terminal-value growth rate.
• ASP allows us to ask what-if and run a new simulation on each change.

Simulation Results - NPV

Terminal-value growth rate = 1%

Simulation Results - NPV

Terminal-value growth rate = 10%
Example – Corporate Valuation Parametric Simulation

- Question: how our simulation estimates would vary if one of the underlying parameters were to change.
  - How sensitive the expected NPV is to the terminal-value growth rate.
- Use parametric simulation techniques to run a simulation once for each value of the parameter we wish to test.
Summary – Parametric Simulation

• Select the cell, choose **Parameters – Simulation** from the Ribbon.

• Enter a lower and upper limit on values for the parameter, or a list of explicit values for the parameter.

• Change the desired number of simulation in task pane Platform tab.

• Create a table (Report) or chart of values for specific statistics of an output cell by running simulations for each value of the input.
Distribution Wizard

Analytic Solver Platform
Summary of Steps – Distribution Wizard \textbf{without} Historical Data

- Choose a currently empty cell, then select \textbf{Distributions} - Distribution Wizard on the Ribbon.

- If you do not have historical data, select No, then determine whether to use a \textbf{discrete} or \textbf{continuous} form.

- Based on underlying process that the variable represents, select an appropriate option.

- Choose a distribution and impose bounds.

- Complete the remaining steps and save it.
Summary of Steps – Fit Distribution Using Distribution Wizard with Historical Data

• Choose a currently empty cell, then select **Distributions - Distribution Wizard** on the Ribbon.

• If you have historical data, select Yes, then select the data cell range.

• Based on data, select an appropriate option.

• Choose Fit data and select the fit options.

• Choose one of the suggested distributions and accept it.
Summary of Steps – **Resample** Historical Data Using Distribution Wizard

- Choose a currently empty cell, then select **Distributions** - Distribution Wizard on the Ribbon.
- If you have historical data, select Yes, then select the data cell range.
- Based on data, select an appropriate option.
- Choose Resample the Data.
- Select a cell to locate the Psi function.
- PsiDisUniform is a custom discrete distribution that takes on the specified values with equal probability.

=PsiDisUniform($C$2:$C$86)
Dependence and Correlation

• Default ASP assumption: each of uncertain variables is independent of all the other uncertain variables.

• Dependent variables – there is a relationship between the uncertain values observed for both uncertain variables.

• Correlation is a statistical measure of the degree to which one variable is related to another.

• The most common parametric measure of correlation is the Pearson product moment correlation coefficient which ranges from -1 to +1.
  • +1 means the two variables are perfectly positively correlated.
  • -1 means the two variables are perfectly negatively correlated.
Summary – Using a Rank Correlation Matrix for Several Variables

- Click the Correlations button on the Ribbon.
- Choose the specific cells for the uncertain variables to correlate.
- Click the “>>” button to include all of them.
- Double click to manually change the black numerical values.
- Or click on any scatterplot, adjust the correlation, and accept it.
- Name the correlation matrix and choose the location in the worksheet to place it.
- Click “Save”.

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Decision Analysis

Using Decision Trees
Decision Analysis

• Decision analysis helps you develop an optimal strategy when faced with multiple stage decisions and uncertain outcomes at each stage.

• Risk analysis provides you with probability information about all possible outcomes at each stage.

• Decision trees provide a graphical representation of the decision-making process.
Example – Building Decision Trees

• Grant Decision Analysis — Multi-Stage— ASP Ribbon → Help → Examples → Decision Tree Examples.
  • Problem — Whether we should submit a grant request proposal, and if we receive the grant which kind of technology we should use to fulfill it.
  • There is a cost to prepare the grant proposal.
  • There is risk we may experience high R&D cost which varies by technology and could have a significant negative impact on our cash flow.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Equipment Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave</td>
<td>$4,000</td>
</tr>
<tr>
<td>Cellular</td>
<td>$5,000</td>
</tr>
<tr>
<td>Infrared</td>
<td>$4,000</td>
</tr>
</tbody>
</table>

Possible R&D Costs

<table>
<thead>
<tr>
<th>Technology</th>
<th>Best Case Cost</th>
<th>Prob.</th>
<th>Worst Case Cost</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave</td>
<td>$30,000</td>
<td>0.4</td>
<td>$60,000</td>
<td>0.6</td>
</tr>
<tr>
<td>Cellular</td>
<td>$40,000</td>
<td>0.8</td>
<td>$70,000</td>
<td>0.2</td>
</tr>
<tr>
<td>Infrared</td>
<td>$40,000</td>
<td>0.9</td>
<td>$80,000</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Example – Building Decision Trees – Using Strategy Table

• Question — how an optimal decision changes as we vary the probabilities for different outcomes?
  • What happens when there is a change in the chance of being awarded the research grant (I25, assumed at 50%), as well as a change in the chance of high research and development costs (Q33, assumed at 10%) when fulfilling the grant.

• Perform sensitivity analysis on our decision.

<table>
<thead>
<tr>
<th>Prob. of Receiving Grant</th>
<th>Probability of High R&amp;D Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>0.0</td>
<td>Don't</td>
</tr>
<tr>
<td>0.1</td>
<td>Don't</td>
</tr>
<tr>
<td>0.2</td>
<td>Infared</td>
</tr>
<tr>
<td>0.3</td>
<td>Infared</td>
</tr>
<tr>
<td>0.4</td>
<td>Infared</td>
</tr>
<tr>
<td>0.5</td>
<td>Infared</td>
</tr>
<tr>
<td>0.6</td>
<td>Infared</td>
</tr>
<tr>
<td>0.7</td>
<td>Infared</td>
</tr>
<tr>
<td>0.8</td>
<td>Infared</td>
</tr>
<tr>
<td>0.9</td>
<td>Infared</td>
</tr>
<tr>
<td>1.0</td>
<td>Infared</td>
</tr>
</tbody>
</table>
Example – Building Decision Trees – Using Strategy Charts

• Question — how an optimal decision changes as we vary the probabilities for different outcomes?

• Strategy chart graphically shows how the optimal decision strategy changes in response to two simultaneous changes in probability estimate.
Example – Building Decision Trees – Exploring Risk

• Instead of simply varying parameters we can use the power of simulation to consider many more possibilities.

• Add distributions for the probabilities of certain events happening and the costs associated with certain outcomes.

• Investigate the mean expected value across each strategy, and compare the distribution of results to better understand risk associated with each strategy.

• The decision with the highest overall expected value.

<table>
<thead>
<tr>
<th>Potential Strategies</th>
<th>Resulting Expected Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Across All Trials</td>
</tr>
<tr>
<td>1. Submit Proposal, Microwave</td>
<td>$27,500</td>
</tr>
<tr>
<td>2. Submit Proposal, Cellular</td>
<td>$28,667</td>
</tr>
<tr>
<td>3. Submit Proposal, Infared</td>
<td>$26,000</td>
</tr>
<tr>
<td>4. Don’t submit</td>
<td>$0</td>
</tr>
</tbody>
</table>

Strategy with the highest Expected value: 2

Net expected value of winning strategy: $13,126 $14,345
Summary – Building Decision Trees

• Click on Decision Tree choice on the Ribbon to create and edit a decision tree.

• Choose Add Node to add a node.

• Select a cell on Excel worksheet – and choose Change Node to change the node.

• Use the Copy Node and Paste Node to copy a subtree (rooted at the selected node) and paste the copy at another position in the decision tree.

• Use Add Branch to add a branch.

• Select a cell on the Excel worksheet and then use Change Branch to change a branch.

• Highlight the best or worst decision strategy by selecting Highlight in the Decision Tree dropdown list.
Session I Recap

• Risk Solver offers the fastest (by far) Monte Carlo simulation in Excel.
  • Speed enables what-if with interactive simulation.
  • Speed matters for advanced analysis: multiple parameterized simulations.

• Risk analysis skills are a career enhancer for business analysts.
  • Know what factors really matter.
  • Give yourself a competitive advantage.
  • Be better prepared for executive decisions.

• Build decision trees by formulating the problem, identifying decision alternatives and chance events, and identifying the chance event outcomes.
Summary

- Business analytics techniques help you analyze existing data, predict future behavior, and find better options for decisions.
- Simulation is a method for better understanding a real-world situation by experimenting with a model that represents that situation.
- Monte Carlo simulation helps to evaluate the impact of uncertainty on a decision.
- Decision analysis helps you develop an optimal strategy when faced with multiple stage decisions and uncertain outcomes at each stage.
  - The goal of decision analysis is to identify the best decision option.
  - The “best” decision should consider the risk preference in evaluating outcomes.
Contact Info

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• Best way to contact me: Consulting@Solver.com
• You may also download this presentation from our website at www.solver.com/training/risksolver-1.
• You can download a free trial version of Analytic Solver Platform at Solver.com.
References

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FRONTLINE SOLVERS

Q & A
Thank You!