How to Consider Risk – Demystifying Monte Carlo Risk Analysis

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Presentation Outline

- What is risk?
- What is gained by considering risk?
- How to model Risk?
- Picking the best risky investment
- Example Monte Carlo Model
- Building Models
- Can you trust Monte Carlo Models?
What is Risk?

• Forecasts consist of a deterministic and a stochastic (random) component
  - Deterministic component is what we know with certainty
    • Historical mean or forecasted average
  - Stochastic component is what we are uncertain about
    • The risk and uncertainty
  - Think of a forecast being the average plus risk or

\[ \hat{Y} = \text{Mean} + \]
Decision Making Without Risk

• Given two investments
  – With the same cash outlay, say $10,000
  – Returns for X average 30%
  – Returns for Y average 20%
• If no risk then invest in alternative X

20% Return Y

30% Return X
Decision Making in Presence of Risk

- Given two investments, X and Y
  - Cash outlay ($10,000) is the same for both X and Y
  - Average return for X averages 30%
  - Average return for Y averages 20%

- What if the risk of returns are known as:

- Simulation estimates the distribution of returns for risky investments

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Risk Is Necessary for Profits

- Without risk there are no excess profits
  - Price is constant, profits are bid out of the industry
  - No excess profits exist for the firm if price is constant
  - No inventive to invest new money in the industry
Risk Is Necessary for Profits

• When price is risky, there is a chance for profits
  – When prices are low there are losses
  – When prices are high there are excess profits

• What investors and business need to know is the shape of the profit distribution
How Do We Include Risk in Decision Making?

• Monte Carlo simulation modeling is most common way to incorporate risk into the investment decision process
  – Monte Carlo simulation is the same as stochastic simulation

• The advent of micro computers and Microsoft Excel has made simulation practical and accessible
Purpose of Monte Carlo Simulation

- “Estimate distributions of economic returns for alternative strategies so the decision maker can make better decisions.”
- Simulation is all about analyzing alternative scenarios
  - Analyzing risk for alternative business decisions
  - Comparing two or more risky investments
  - Analyzing investment alternatives or change in management of an existing firm
  - Analyzing alternative retirement plans
Benefits of Including Risk

- Reduce the chance of a surprise if we include all sources of risk prior to making a decision
  - Always have multiple risky variables which affect an investment decision, such as:
    - Prices of Inputs, Price of Output, Production, Input Availability, Labor, Policy, etc.
  - Can never include all, but can include most all of the important sources of risk
What Can we Get from a Monte Carlo Business Investment Model?

- Estimate shape of the distribution for profits or returns
- Calculate confidence intervals for investment payoffs or profit
- Probability of profits and loss
- Probability of positive cash flows
- Probability of economic viability
- Probability of bankruptcy
Shape of the Distribution for Profit or Returns

Probability Distribution for Return on Equity with 90% CI
Probabilities for Targeted Levels of Returns

Probability of Alternative Rates of Return
Monte Carlo Simulation and Excel Spreadsheet Models

• Until the Mid-1990’s Monte Carlo simulation was reserved for large corporations and universities with “big” computers

• Today we regularly see Excel spreadsheet models used for all aspects of business and investment decisions

• Most all of these Excel simulation models are deterministic
  - Do not include risk on random variables
  - Usually run for Best case and Worst case scenarios or what if scenarios
Making an Excel Spreadsheet Model a Monte Carlo Simulation Model

• Excel Add-Ins exist for users to easily convert spreadsheet models into Monte Carlo risk analysis models
  – Simetar, Crystal Ball, @Risk, and others

• An Excel model can be converted to a Monte Carlo simulator in 3 easy steps:
  – Convert the risky variables from “What if’s” to random variables
  – Simulate the model a large number of iterations
  – Develop decision analysis reports for the results
Common Types of Business Based Monte Carlo Simulation Models

- Business Management Analysis
- Portfolio Analysis
- Retirement Analysis
- Insurance Option Analysis
- Policy Analysis
- Economic Feasibility Analysis for New Businesses
  - Alternative feedstocks for renewable fuels
  - Returns for new technologies
  - Maximum prices that can be charged for new technologies
  - Adding exotic enterprises to existing businesses
What’s In a Monte Carlo Business Simulation Model?

• One or more random variables

• Business models include
  – Income Statement
    • Receipts and Expenses plus Interest >> Net Cash Income
  – Cash Flow Statement
    • Cash Inflows and Cash Outflows >> Ending Cash
  – Balance Sheet
    • Assets and Liabilities >> Net Worth
  – Financial Ratios
    • ROA, ROE, Debt to Assets, etc.
What Is The Monte Carlo Process?

• Repeat the simulation of the model a large number of times – 500 iterations
  - Each iteration uses a different random value for every random variable
  - Random values are drawn at random from specified distributions
  - Repeat process 500+ times to sample from all parts of the distributions for random variables

• All of this is done for the analyst by the Excel Add-In for risk analysis
Outputs for a Monte Carlo Simulation Model?

• 500+ values simulated for each of the key output variables (KOVs) of interest
• The 500+ values represent an estimated probability distribution for the KOVs
• KOV distributions for Net Present Value or ROI are used to rank risky alternatives
• Simulation is at its best when we simulate a base vs. alternative scenarios
  – Thus using simulation to analyze and rank risky alternatives
Example of a Simple Monte Carlo Simulation Model for a Business

Total Revenue = Price * Production

Total Costs = Fixed Costs + Variable Costs

Profits = Total Revenue - Total Costs
Example of a Simple Monte Carlo Simulation Model for a Business

• Key Output Variable is Profit for the business model

• Best displayed as a Cumulative Distribution
  – Able to read probabilities on vertical axis
Ranking Risky Alternatives

• Much has been written about ranking risky alternatives and decision making
• Most of the literature relies on complex utility estimation and analysis
• The remainder of the literature relies on simple rules of thumb that do not work
• I will present several simple methods and then two new methods that are theoretically sound but simple to use
Ranking Risky Alternatives

- **Average return**
  - Pick alternative with highest average return; works if investor is risk neutral

- **Best Case and Worst Case**
  - Do you want to base your investment strategy on something that could happen 1\% of the time?
  - Avoiding worst case may preclude upside benefits
Ranking Risky Alternatives

• Minimize risk at all costs
  - Could minimize the chance of a large return
  - This is the reason we need to estimate the shape of the distribution for returns

• These simple rules were developed if you do not know the shape of the return’s distribution
New Methods for Ranking Risky Alternatives

• Demonstrate two modern methods for ranking risky alternatives that are based on knowing the shape of the distribution for returns or profit

• A portfolio problem is used to demonstrate risk ranking; assume the following:
  - Client is interested in 9 stocks
  - Have annual returns plus change in value for 11 years to represent risk in the market
  - Analyze 7 alternative portfolios to start with
StopLight Chart for Displaying Risk of Achieving Target Returns

- Analyst specifies the target returns based on investors preferences
- Green is good … Red is Bad … Yellow is so so so

StopLight Chart for Ranking Alternative Portfolios Based on Probability of Returns Less Than 0.05 and Greater Than 0.17
Stochastic Efficiency Combines Utility Analysis and Graphics

- Investors self-identify their level of risk aversion (RA): None, Moderate, Extreme
- Prefer the alternative with the highest Certainty Equivalent for their RA
Demonstrate a Retirement Simulation Model

• I developed this model a few years ago
• Purpose was to scare students into thinking about retirement savings
• Inputs include
  – Current savings, age, expected salaries, annual savings, investment returns, age to retire, spending at retirement, etc.
• Outputs include
  – Age when run out of cash, probability of being broke each year after retirement
Can We Trust All Monte Carlo Models? -- NO!

- We need to know the following:
  - What are the random variables?
  - How are the random variables modeled?
    - Normal distributions are bad?
    - How were the distribution parameters estimated?
    - Were random variables correlated?
  - How was the model validated and verified?
  - How many iterations were simulated?
  - How are the results analyzed?
  - How are alternatives ranked?
Can You Build Your Own Models? -- YES

• Monte Carlo simulation models are not difficult to develop and use
• Excel skills are a necessity
• An Excel Add-In for risk is essential
• Workshops are available to learn how to build Monte Carlo simulation models
• Can easily convert existing Excel models to Monte Carlo simulation models
Advantages of Building Your Own Monte Carlo Simulation Model

• You know what is in the model and how it operates – self validation
• You can change the model to meet your clients’ needs
• You control the input data and random variables
• You develop customized reports and analyses to meet your clients’ needs
• You will trust the results more than if you use an off-the-shelf model or on-line model
Thank You

Contact me for information about simulation modeling workshop and the Simetar simulation add-in for Excel

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Learn more about Simetar at
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