MGB 206: Decision Making and Management Science

Sanjay Saigal

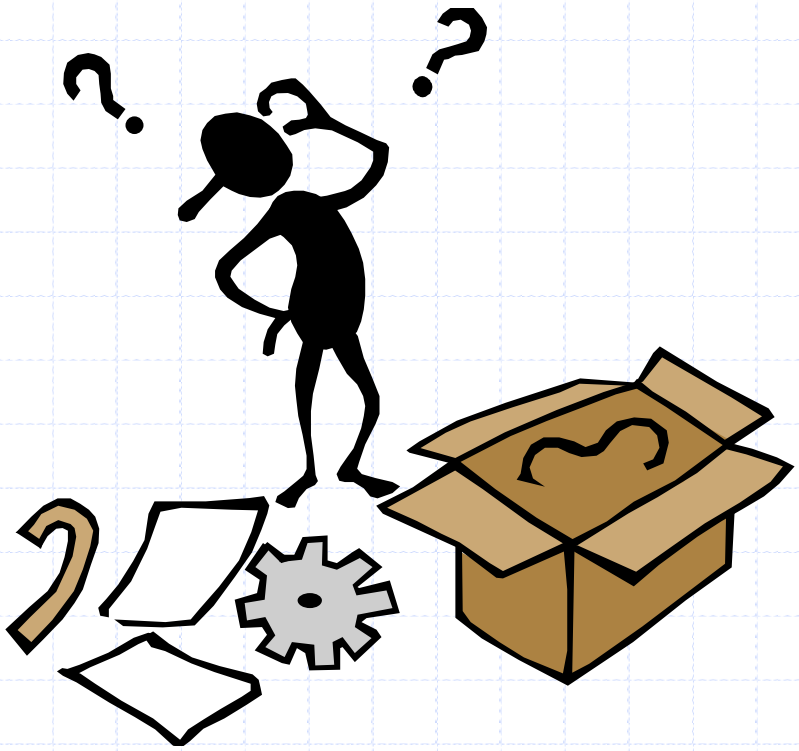
ssaigal@ucdavis.edu

650 283 1985

Lesson Plan: Session 3

1. Recalling Session 2
2. Theoretical concepts
3. Simulation-optimization
4. Simulation wrap-up

What We Discussed Last Time



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Basics: Elementary Concepts

- Uncertainty
- Randomness
- Risk

Basics: Graphs

- Histogram: the "shape" of an uncertain number (= "probability distribution"?)
- Cumulative graph: probability that uncertain number < given quantity

Basics: Central Tendency

- For an uncertain number
  - Mean: average value
  - Median: "middle" value
  - Mode: most often seen value

Basics: Dispersion

- Variance (σ^2): subtract mean from uncertain number, square it, and take the average of all such numbers
- Standard deviation (σ): Square root of variance

Basics: Diversification

- When independent uncertain numbers are added together, they become less uncertain!
- This amazing fact arises from the Central Limit Theorem

Exercise: Max Of 2 Randoms

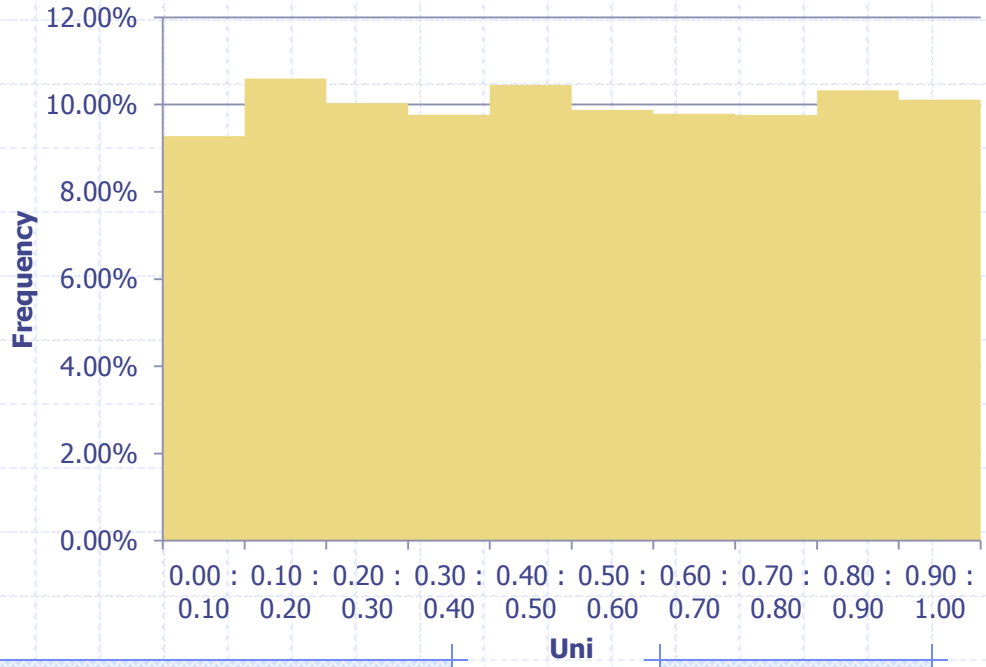
- What does the distribution of "the higher of two uniform variables" look like?

Basics: Sample Distributions

- Choosing values for uncertain numbers from rand() is an example of sampling
- We have used canned distributions
  - Uniform
  - Triangular
- Normal distribution also common
- Or, use history: "Bootstrapping"

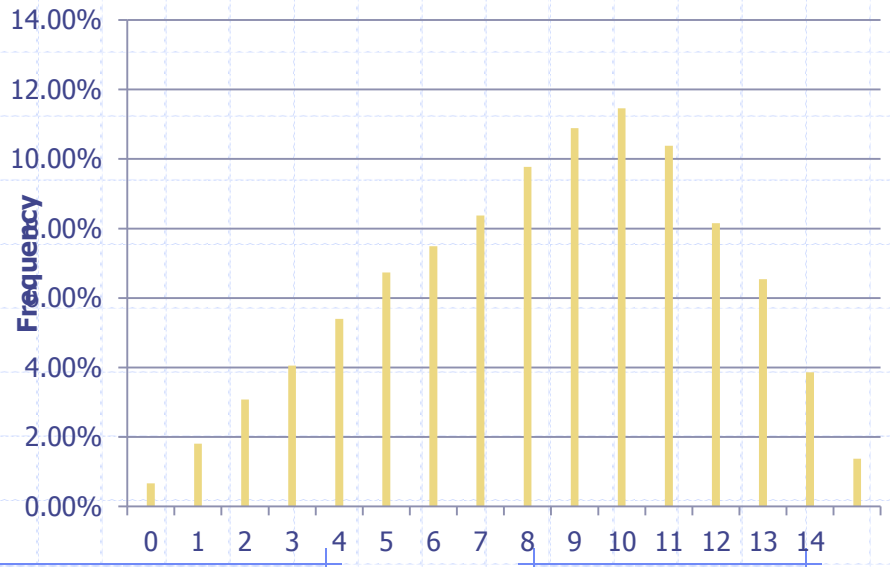
Uniform Distribution

- Specify: min and max
- Any value between min and max equally likely
- Examples?



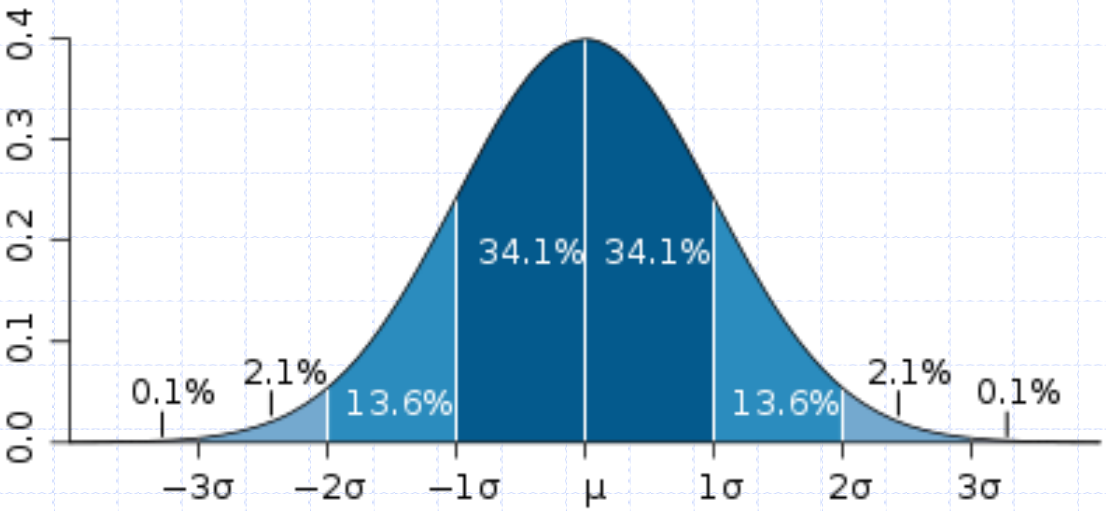
Triangular Distribution

- Specify: min, average and max
- Artificial, rarely found in nature
- Use as first approximation
  - Often elicited from non-quants



Normal Distribution

- Specify: average and std. deviation
- Average of many independent uncertainties
- Overused



Bootstrapping / Re-sampling

- History may be your best guide
- Use it
  - Unless you have clear reasons not to
- Simulation use
  1. Pick sample from data-set
  2. Replace
  3. Repeat

Exercise: Fund Diversification

- Three investment options
  - Domestic (Normal, mean = 0.1, sd= 0.1)
  - Foreign (Normal, mean = 0.1, sd= 0.1)
  - Half and half
- Run simulation (1000 trials)
- Describe what you found

Convergence Of Simulation

- How many trials are enough?
- Standard Error = standard deviation of output cell mean divided by #trials
  - Central limit theorem says it is approximately normally distributed
  - We can use that to estimate error range
- Doubling accuracy requires four times the number of trials

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Exercise: Inventory Planning

- Perishable drug with uncertain demand
  - Current stocking policy: 5 cases /week
  - Have actual demand data for 36 weeks
- Excess stock destroyed at end of week
  - Cost: $50 /case
- Stockouts addressed by airlifting extra
  - Most likely cost: $150 /case
  - It could be between $100 to $300

Ex: Inventory Planning (cont'd)

- Examine the inventory spreadsheet
  - What is the average demand?
  - What is the total cost at average demand and average air freight cost?
- What is wrong with this picture?

Ex: Inventory Planning (cont'd)

- Key decisions
  - Bootstrap historical demand
  - Randomize air freight cost
- Run a simulation!

Flaw of Averages

- Average inputs don't lead to average outputs
- Equivalently: plans based on average assumptions are usually wrong

Levels of Analysis

- Average case analysis: Worse than nothing
- Simulation: Describes situation
- Optimization: Prescribes action

Example: What's Best?

- Let's continue with inventory model
- What can we say about the *optimum* stocking level?
- Let's run a parametrized simulation and find out

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Example: Advertising

- Load advertising hypothesis spreadsheet
- Firm places ads in 10 of 30 markets
- Before/after sales data say:
  - Average sales in advertised markets increased 3.4%

Q Was the advertising budget well-spent?

  - (Could the sales increase be coincidental?)

Key Learnings: Simulation

- Highly accessible to the non-expert
- Turns uncertainty into insight
  - Sidesteps Flaw of Averages
- Easily done on the average laptop
- Widely applicable, not limited by industry, application, etc.
- By nature, it's descriptive
  - You still need to decide what to do next

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