Week 4: Balancing Risk and Reward Using Simulation

- Modeling Uncertainty: From Scenarios to Continuous Distributions
- Example: Designing a New Apartment Building
- Connecting Random Inputs and Random Outputs in a Simulation
- Setting up and Running a Simulation in Excel
- Analyzing and Interpreting Simulation Output
- Evaluating Alternative Decisions using Simulation Results

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Week 4: Balancing Risk and Reward Using Simulation

- Modeling Uncertainty: From Scenarios to Continuous Distributions
- Example: Designing a New Apartment Building
- Connecting Random Inputs and Random Outputs in a Simulation
- Setting up and Running a Simulation in Excel **Session 2**
- Analyzing and Interpreting Simulation Output
- Evaluating Alternative Decisions using Simulation Results

Example: Designing a New Apartment Building

- The Stargrove Development Corporation is planning a new apartment building in Philadelphia
- The building will have two kinds of apartments, regular and luxury
- The building will have 15 floors, with the lower floors housing regular apartments and higher floors – luxury apartments
- Each floor will contain only one kind of apartments – either regular or luxury
- Each floor can house either 8 regular apartments or 4 luxury apartments
- Stargrove needs to decide how many floors to allocate to regular apartments and how many floors to allocate to luxury apartments

Example: Designing a New Apartment Building

- Stargrove expects to complete construction within the next year, and during that period, it plans to sell apartments to prospective buyers

- Stargrove expects to obtain a profit of P_R = \$500,000 for each regular apartment it sells during next year, and a profit of P_L = \$900,000 for each luxury apartment it sells during the next year

- If, at the end of the next year, there are unsold apartments, Stargrove will sell all of them to a real estate investment company at a “salvage” profit of S_R = \$100,000 for each remaining regular apartment and S_L = \$150,000 for each luxury apartment

Example: Designing a New Apartment Building

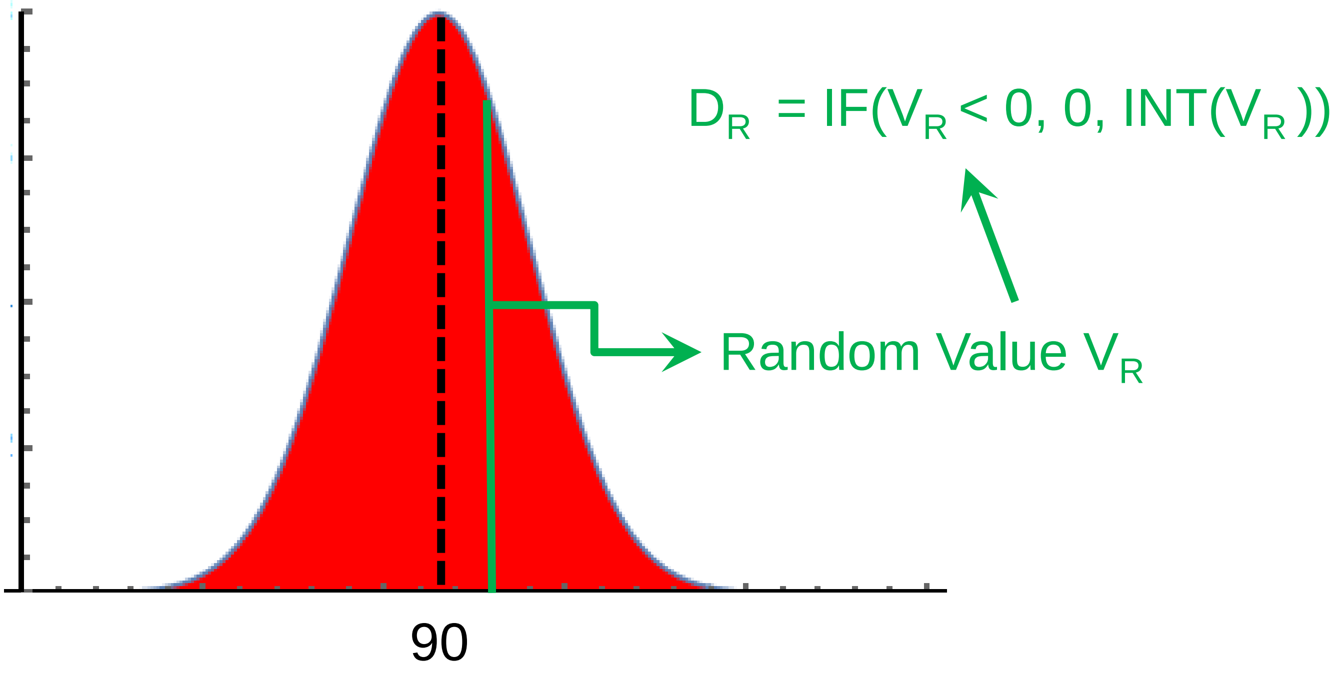
- Stargrove analysts project that at the price levels that the company will charge for the apartments, the total demand for **regular apartments** over the next year will be **normally distributed with a mean of 90 and a standard deviation of 25**, and the total demand for **luxury apartments** over the next year will be **normally distributed with a mean of 10 and a standard deviation of 3**. The demands for two apartment types will be modeled as independent (non-correlated) random variables

- Normal random variables can take fractional and negative values, while the demand values must be positive and integer. The values used for estimating the reward and risk measures will take this into account

Simulation: Random Inputs and Random Outputs

- The profit (in $):

  Π = 500,000*min(D_R,R) + 900,000*min(D_L,L) + 100,000*(R-min(D_R,R)) + 150,000*(L-min(D_L,L))

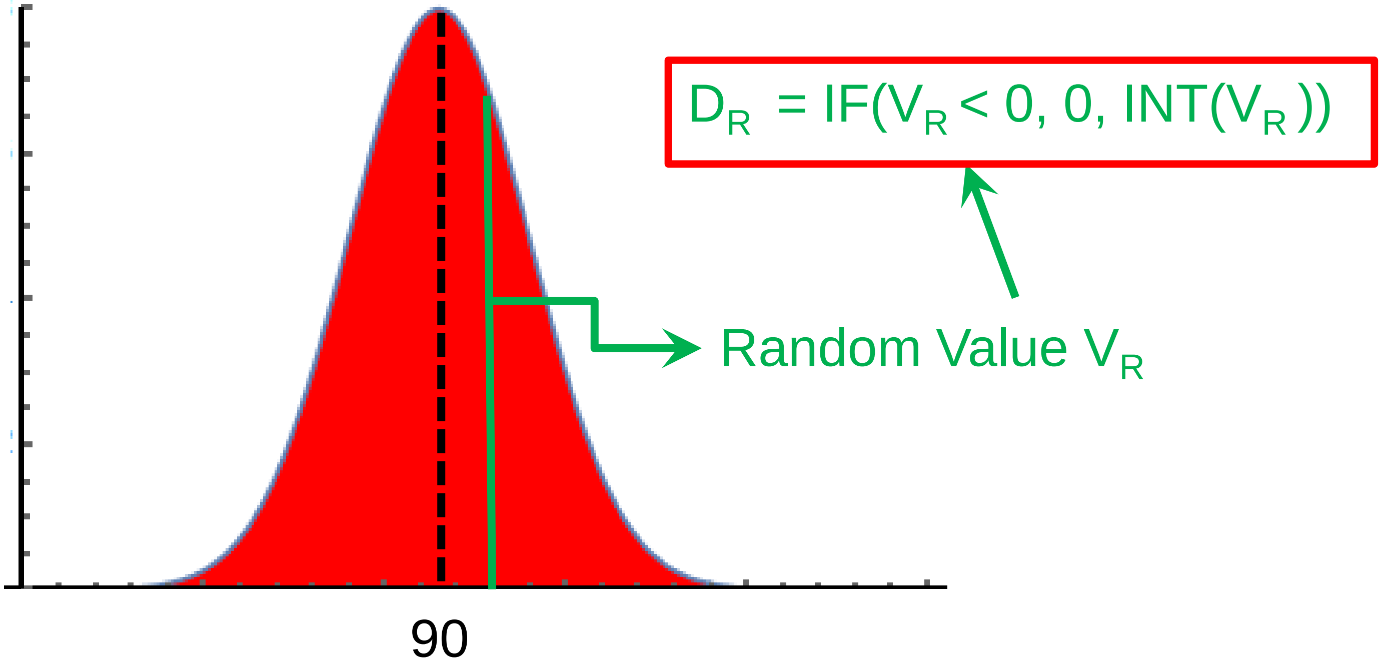


- Since the demand value D_R must be positive and integer, we will "adjust" the random value V_R if necessary

Simulation: Random Inputs and Random Outputs

- The profit (in \$):

  $\Pi = 500{,}000*\min(D_R,R) + 900{,}000*\min(D_L,L) + 100{,}000*(R-\min(D_R,R)) + 150{,}000*(L-\min(D_L,L))$



- Since the demand value D_R must be positive and integer, we will “adjust” the random value V_R if necessary

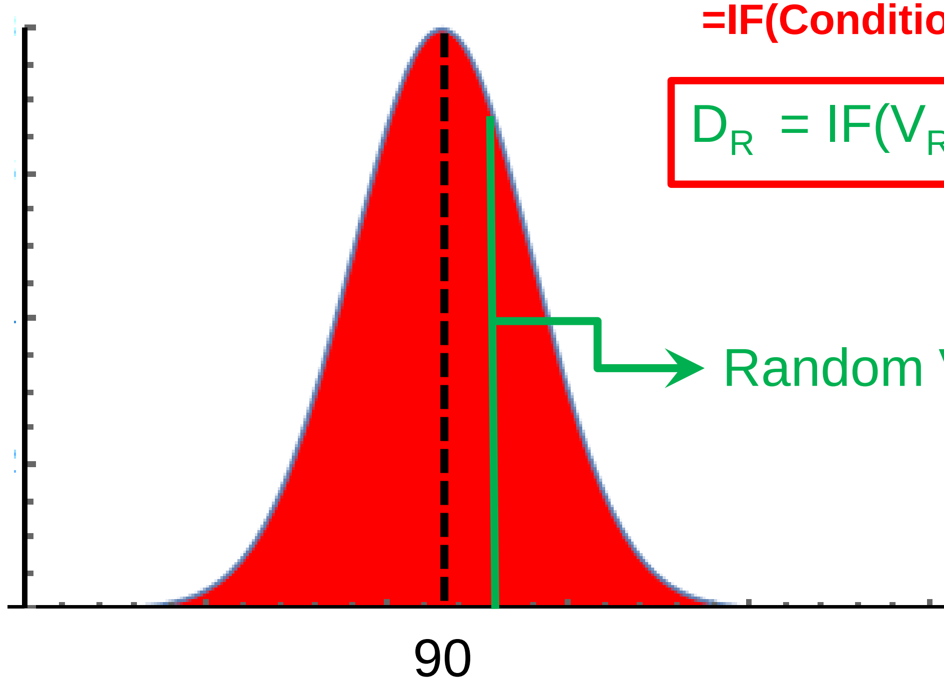
Simulation: Random Inputs and Random Outputs

- The profit (in \$):

  $\Pi = 500{,}000 \cdot \min(D_R,R) + 900{,}000 \cdot \min(D_L,L) + 100{,}000 \cdot (R-\min(D_R,R)) + 150{,}000 \cdot (L-\min(D_L,L))$

=IF(Condition, Choice1, Choice2)

$\boxed{D_R = \text{IF}(V_R < 0, 0, \text{INT}(V_R))}$



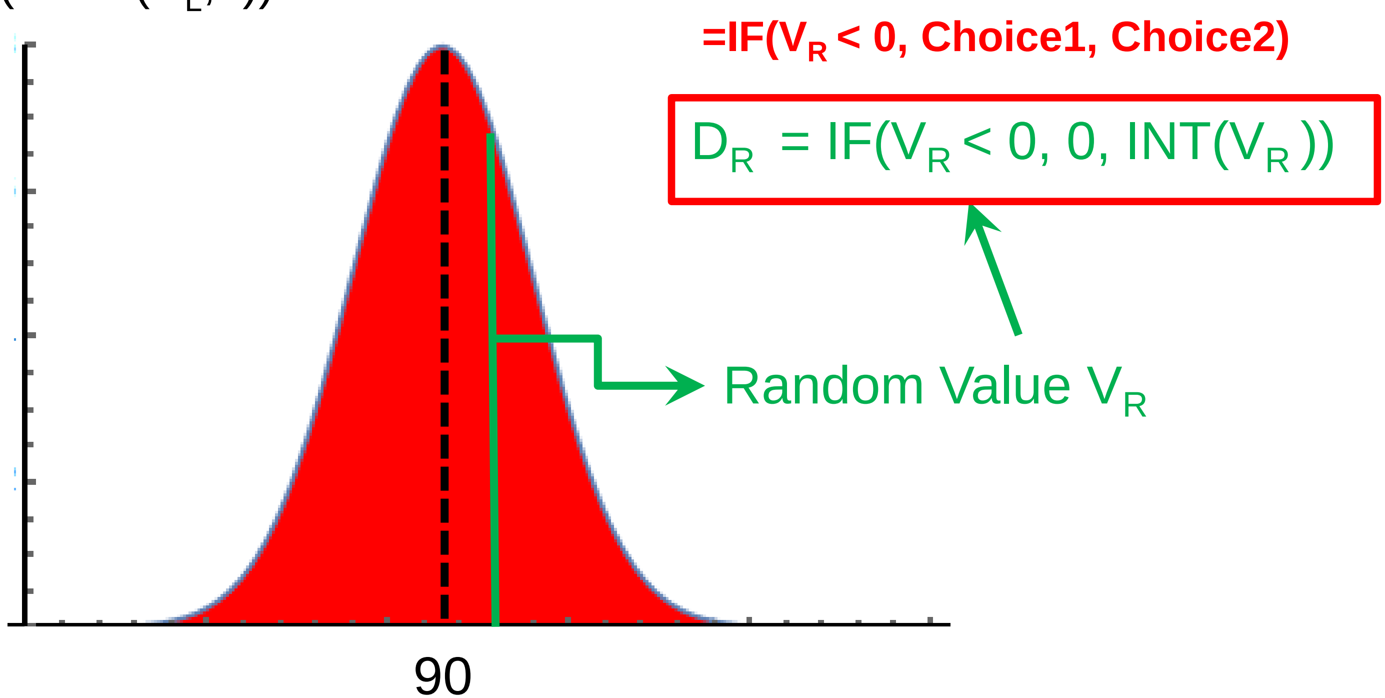
Random Value V_R

- The IF function looks at the **Condition:** if the **Condition** is true, then the value of IF is equal to **Choice1**; if the **Condition** is false, then the value of IF is equal to **Choice2**

Simulation: Random Inputs and Random Outputs

- The profit (in $):

  $\Pi = 500{,}000^*\min(D_R,R) + 900{,}000^*\min(D_L,L) + 100{,}000^*(R-\min(D_R,R)) + 150{,}000^*(L-\min(D_L,L))$



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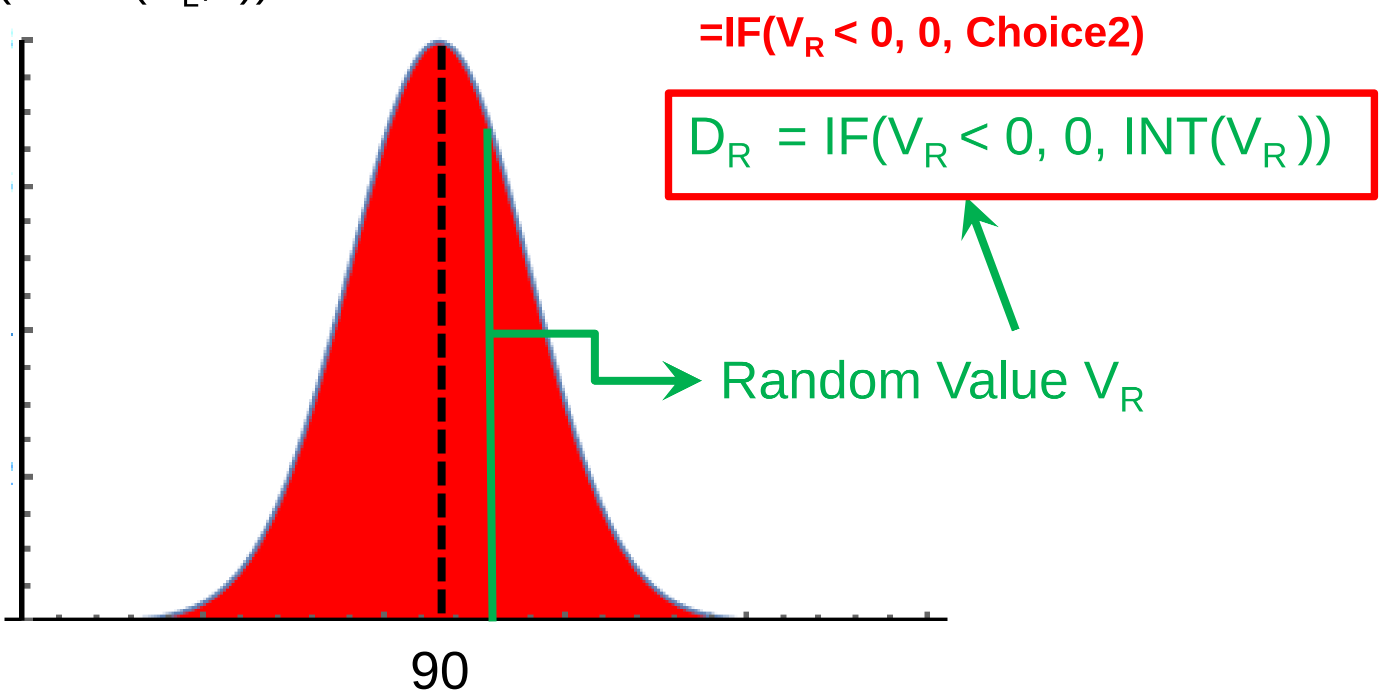
Simulation: Random Inputs and Random Outputs

- The profit (in \$):

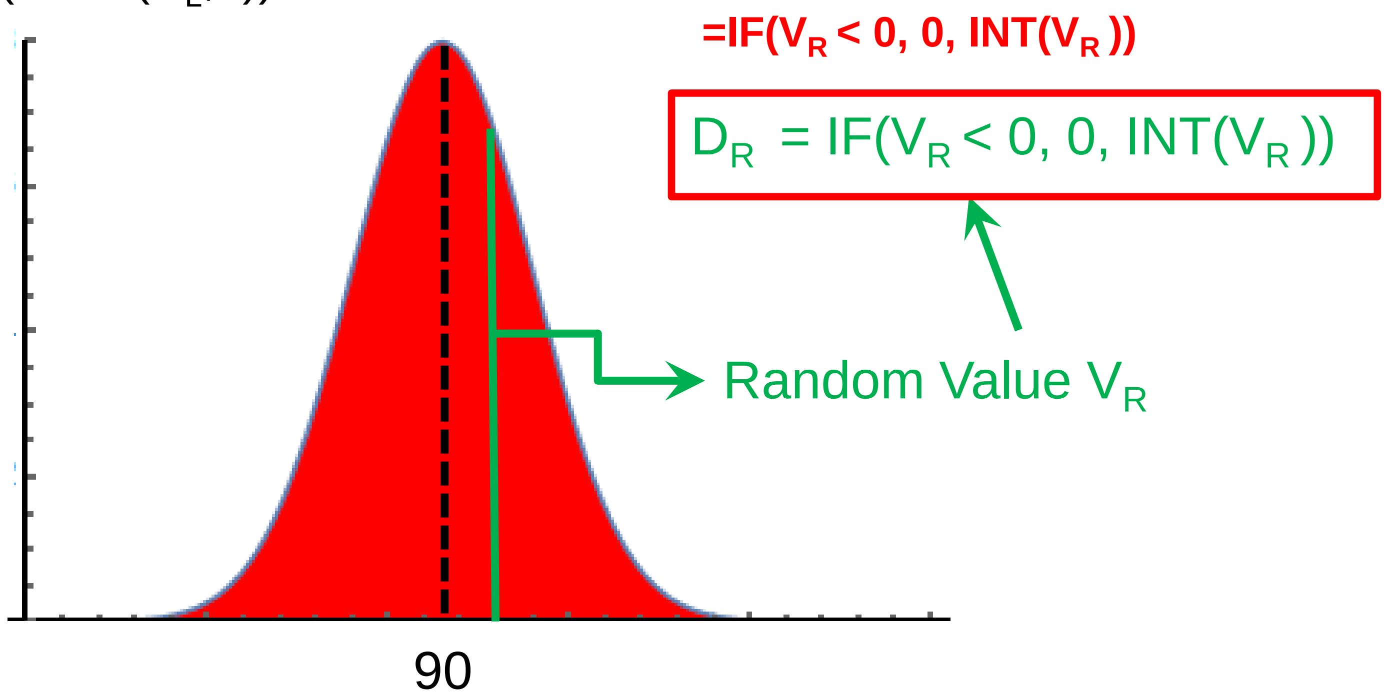
  Π = 500,000*min(D_R,R) + 900,000*min(D_L,L) + 100,000*(R-min(D_R,R)) + 150,000*(L-min(D_L,L))



- The IF function looks at the **Condition:** if the **Condition** is true, then the value of IF is equal to **Choice1**; if the **Condition** is false, then the value of IF is equal to **Choice2**

Simulation: Random Inputs and Random Outputs

- The profit (in $):
  $\Pi = 500{,}000*\min(D_R,R) + 900{,}000*\min(D_L,L) + 100{,}000*(R-\min(D_R,R)) + 150{,}000*(L-\min(D_L,L))$

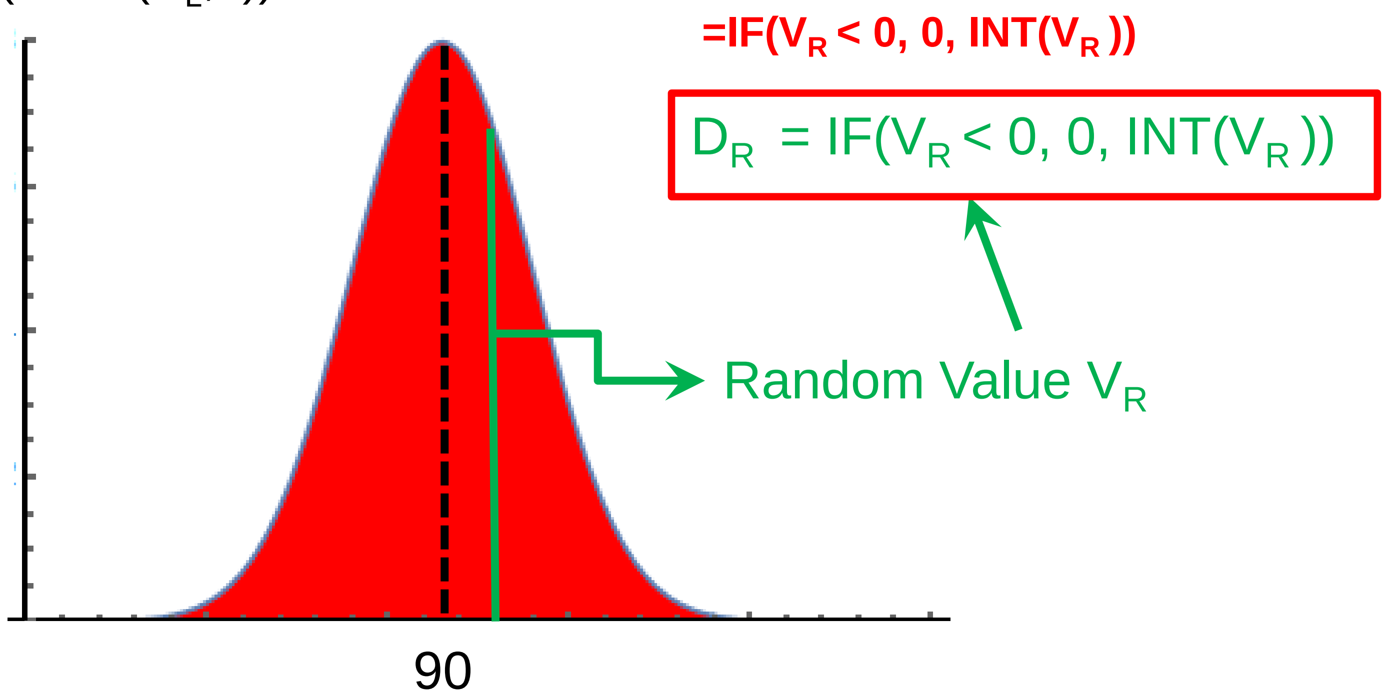


- The IF function looks at the **Condition:** if the **Condition** is true, then the value of IF is equal to **Choice1**; if the **Condition** is false, then the value of IF is equal to **Choice2**

Simulation: Random Inputs and Random Outputs

- The profit (in \$):

  $\Pi = 500{,}000 * \min(D_R,R) + 900{,}000 * \min(D_L,L) + 100{,}000 * (R-\min(D_R,R)) + 150{,}000 * (L-\min(D_L,L))$

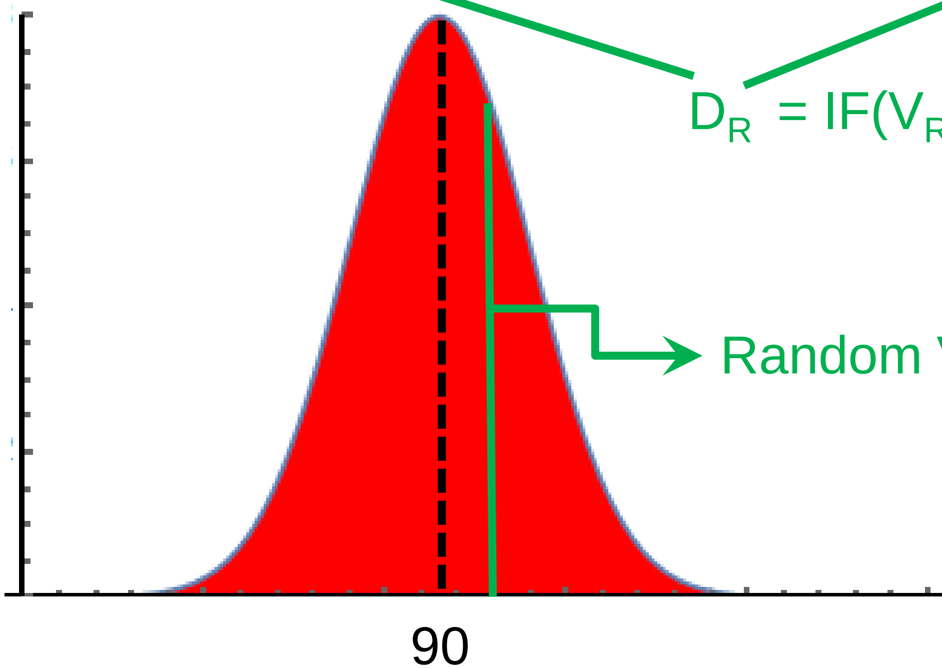


- $INT(V_R)$ calculates the integer part of V_R. For example, INT(92.9) = 92

Simulation: Random Inputs and Random Outputs

- The profit (in \$):

  $\Pi = 500{,}000 * \min(D_R, R) + 900{,}000 * \min(D_L, L) + 100{,}000 * (R - \min(D_R, R)) + 150{,}000 * (L - \min(D_L, L))$



$D_R = IF(V_R < 0, 0, INT(V_R))$

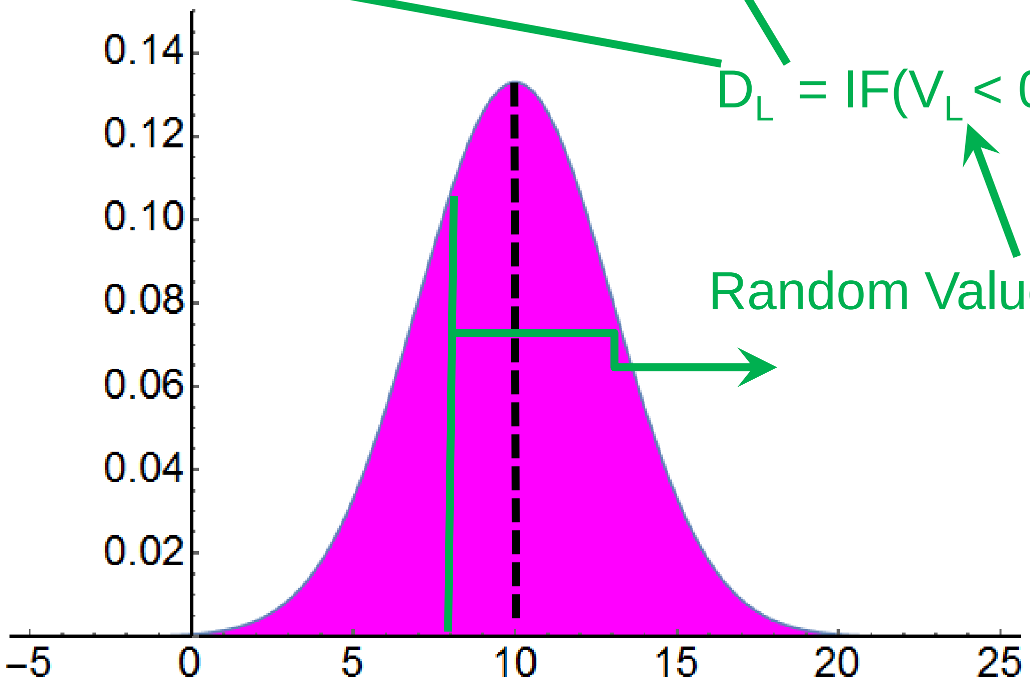
Random Value V_R

Simulation: Random Inputs and Random Outputs

- The profit (in $):

  Π = 500,000*min(D_R,R) + 900,000*min(D_L,L) + 100,000*(R-min(D_R,R)) + 150,000*(L-min(D_L,L))

D_L = IF(V_L < 0, 0, INT(V_L))



Random Value V_L

Simulation: Random Inputs and Random Outputs

- The profit (in $):

  Π = 500,000*min(D_R,R) + 900,000*min(D_L,L) + 100,000*(R-min(D_R,R)) + 150,000*(L-min(D_L,L))

- We can repeat this simulation step (called the "**simulation run**") as many times as necessary to generate the "**sample distribution**" of the "output" value Π

- Once this "sample distribution" of the random output is generated, it can be used to calculate estimates for any reward and risk measures

- We will use Excel for running the simulation and for the analysis of the simulation output

- Stargrove_0.xlsx