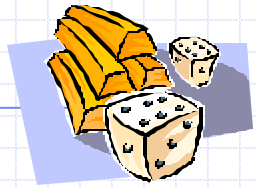
# Monte Carlo Simulation in EXCEL



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## *Risk Analysis*

- We routinely use projections in our decisions (e.g., what will be the cost of materials, future interest rates, future employment numbers, future demand, etc.)
- There is uncertainty associated with whatever value we may choose to use.
- This uncertainty produces an element of risk in our decision making.
- Will often use the most likely (average) value for this uncertain variable -- of course, this tells us nothing about variability!

Source: Cliff Ragsdale, Spreadsheet Modeling and Decision Analysis

## An Inventory Example

A supply firm carries a piece of equipment for which demand is random with an average of five units per month. The firm stocks five units of inventory to satisfy demand.

The cost of maintaining the inventory has two components:

* If the demand is less than the number stocked, a $50 storage charge is incurred for every unit stocked in excess of demand.
* If the demand is greater than the number stocked, an air freight cost of $150 per unit is incurred for the shortfall.

This situation is reflected in the spreadsheet model I will show you.

1. I plug in average demand and …
2. Lessons learned?

Source: Sam Savage, OR/MS Today, Dec 94, p. 41-42

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## How to Analyze Risk?

- **Best case / Worst case analysis**
  - easy to do
  - tells us nothing about distribution within range
  - or about probability of any particular outcome
- **What-If analysis** -- change values of certain input variables to observe effect on performance measure.
  - which values do you test? reflect randomness?
  - might require large number of scenarios to validly represent underlying variability
  - doesn't allow us to represent the distribution of the performance measure

Source: Cliff Ragsdale, Spreadsheet Modeling and Decision Analysis

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## Simulation

- objective: describe the distribution and characteristics of the possible values of the bottom line performance measure given the possible values and behavior of the independent variables.
- essentially playing out many what-if scenarios, except:
  - values are assigned in a non-biased way
  - user doesn't have to worry about it

  (we are randomly generating sample values for each uncertain input variable and then computing the performance measure value)

Source: Cliff Ragsdale, Spreadsheet Modeling and Decision Analysis

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## Classification of Decision Models

| *Decision problem is:* | Major variables in a decision problem are: | |
|---|---|---|
| | *Certain* | *Uncertain* |
| Simple | Case models | Decision analysis (decision trees) |
| Complex | Case models<br>Linear and integer programming | **Simulation** |
| Dynamic | Inventory models<br>PERT models | **Simulation**<br>Inventory models<br>Queuing models |

Source: Bonini, Hausman and Bierman, Quantitative Analysis for Management, Irwin, p. 7

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# A Corporate Health Insurance Example

Lisa Pon has just been hired as an analyst in the corporate planning department of Hungry Dawg Restaurants. Her first assignment is to determine how much money the company needs to accrue in the coming year to pay for its employees' health insurance claims. Hungry Dawg is a large, growing chain of restaurants that specialize in traditional southern foods. The company has become large enough that it no longer buys insurance from a private insurance company. The company is now self-insured, meaning that it pays health insurance claims with its own money (although it contracts with an outside company to handle the administrative details of processing claims and writing checks.)

The money the company uses to pay claims comes from two sources: employee contributions (or premiums deducted from employees' paychecks), and company funds (the company must pay whatever costs are not covered by employee contributions.) Each employee covered by the health insurance plan contributes $125 per month. However, the number of employees covered by the plan changes from month to month as employees are hired and fired, quit or simply add or drop health insurance coverage. A total of 18,533 employees were covered by the plan last month. The average monthly health claim per covered employee was $250 last month.

Source: Cliff Ragsdale, Spreadsheet Modeling and Decision Analysis

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# Spreadsheet Model

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | Hungry Dawg Restaurants | | | |
| 3 | | | | | | | |
| 4 | Initial Conditions: | | | | Assumptions: | | |
| 5 | Number of Covered Employees | | | 18,533 | Increasing | 2% | per month |
| 6 | Average Claim per Employee | | | $250 | Increasing | 1% | per month |
| 7 | Amount Contributed per Employee | | | $125 | Constant | | |
| 8 | | | | | | | |
| 9 | | Number of | Employee | Avg Claim | Total | | Company |
| 10 | Month | Employees | Contributions | per Emp. | Claims | | Cost |
| 11 | 1 | 18,904 | $2,362,958 | $252.50 | $4,773,174 | | $2,410,217 |
| 12 | 2 | 19,282 | $2,410,217 | $255.03 | $4,917,324 | | $2,507,107 |
| 13 | 3 | 19,667 | $2,458,421 | $257.58 | $5,065,827 | | $2,607,406 |
| 14 | 4 | 20,061 | $2,507,589 | $260.15 | $5,218,815 | | $2,711,226 |
| 15 | 5 | 20,462 | $2,557,741 | $262.75 | $5,376,423 | | $2,818,682 |
| 16 | 6 | 20,871 | $2,608,896 | $265.38 | $5,538,791 | | $2,929,895 |
| 17 | 7 | 21,289 | $2,661,074 | $268.03 | $5,706,063 | | $3,044,989 |
| 18 | 8 | 21,714 | $2,714,295 | $270.71 | $5,878,386 | | $3,164,091 |
| 19 | 9 | 22,149 | $2,768,581 | $273.42 | $6,055,913 | | $3,287,332 |
| 20 | 10 | 22,592 | $2,823,953 | $276.16 | $6,238,802 | | $3,414,849 |
| 21 | 11 | 23,043 | $2,880,432 | $278.92 | $6,427,214 | | $3,546,782 |
| 22 | 12 | 23,504 | $2,938,041 | $281.71 | $6,621,315 | | $3,683,275 |
| 23 | | | | | Total Company Cost | | $36,125,850 |
| 24 | | | | | | | |

Source: Cliff Ragsdale, Spreadsheet Modeling and Decision Analysis

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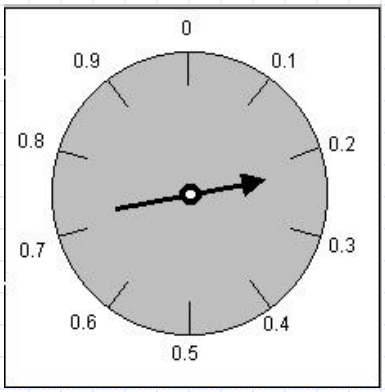
## Conceptual Building Block




Imagine that your company's profit for the next year is determined by the twirl of the spinner and then the result multiplied by $1 million.

Further suppose that if the result is less than $200,000 you will be laid off.

Source: Sam Savage, INSIGHT: Business Analysis Tools for Microsoft EXCEL.

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## Quickly Jot Answers

Test your intuition by answering the following:

1. If you faced this situation over many, many years, what would be your profit on average?
2. What is your likelihood of being laid off?
3. What should you tell the boss when he/she demands a "number" for profit?
4. Create a bar chart showing the percentage of times profit is likely to fall between 0 and .2, .2 and .4, etc.

Source: Sam Savage, INSIGHT: Business Analysis Tools for Microsoft EXCEL.

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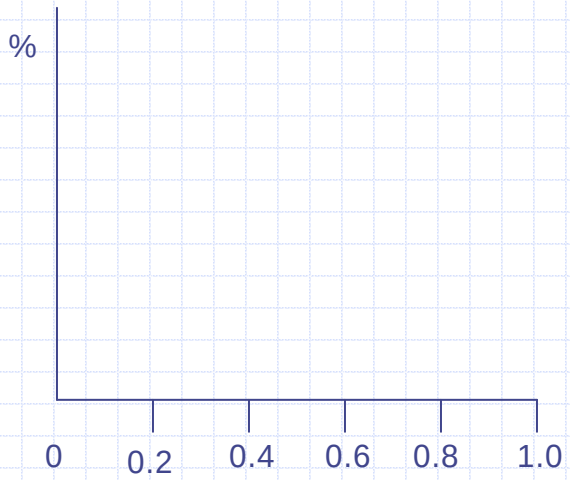
## Sketch




Source: Sam Savage, INSIGHT: Business Analysis Tools for Microsoft EXCEL.

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## Another Model -- More Questions

Suppose this time that profit is determined by two spins, averaged together, and then multiplied by a million dollars.

1. If you faced this situation over many, many years, what would be your profit on average?
2. What is your likelihood of being laid off?
3. What should you tell the boss when he/she demands a "number" for profit?
4. Create a bar chart showing the percentage of times profit is likely to fall between 0 and .2, .2 and .4, etc.

Source: Sam Savage, INSIGHT: Business Analysis Tools for Microsoft EXCEL.

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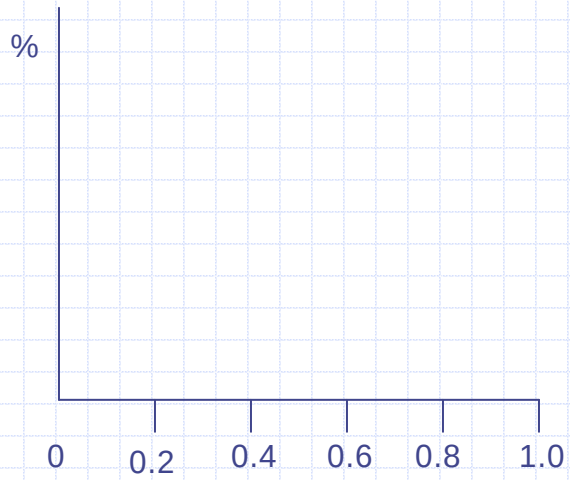
## Sketch




Source: Sam Savage, INSIGHT: Business Analysis Tools for Microsoft EXCEL.

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## Incorporating Uncertainty

From analyzing historical data we have determined the following:

The change in the number of covered employees from one month to the next is expected to vary **uniformly** between a 3% decrease and a 7% increase.

The average month claim per employee can be modeled as a **normally distributed** random variable with a mean increase of 1% per month and a standard deviation of 3%.

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## *Representing Probability Distributions*

RNG for the discrete uniform distribution: INT(n*RAND())+a

where a = first integer of the range and n = number of distinct possible outcomes

RNG for the continuous uniform distribution: a + (b-a)*RAND()

where the modeled random variable can assume any value between the points a and b

RNG for the symmetric triangular distribution:

a + (b-a)*(RAND() + RAND() ) / 2

where a and b are the extreme points and ((b+a)/2) is the most likely

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## *Representing Probability Distributions -- MORE*

RNG for the normal distribution: =NORMINV(RAND(),μ,σ)

with mean μ and standard deviation σ

RNG for the exponential distribution: = -1/λ*LN(RAND())

where 1/λ represents both the mean and standard deviation

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## Simulation Exercise

| | |
|---|---|
| revenue | 100 |
| costs | 75 |
| profit | 25 |

Create a simple spreadsheet with cells for revenue, costs and profit. (profit = revenue - costs)

Revenue is a probabilistic random variable modeled by a **normal** distribution with a mean of 100 and a standard deviation of 5. [=NORMINV(RAND(),μ,σ)]

Cost is a **uniform** random variable with a range of 50 to 75. [=a + (b-a)*RAND() | where a = min and b = max]

Simulate the profit function for 100 replications. Determine the expected value, the standard deviation, plot the cumulative distribution and calculate the 95% confidence interval for the expected value.

## Simulate using a Data Table

1. Select range of cells.
2. Select Data on the main menu.
3. Click Table.
4. In the table dialog box enter any blank cell for the Column input cell.
5. Click OK.

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## Representing Probability Distributions

**Multinomial distributions:**

| Probability | Value |
|---|---|
| 0.1 | $8 |
| 0.2 | $9 |
| 0.3 | $10 |
| 0.2 | $11 |
| 0.2 | $12 |

These probabilities are entered in the form of:
0 and up to 0.1
0.1 and up to 0.3
0.3 and up to 0.6
0.6 and up to 0.8
0.8 and up to 1.0

| | A | B | C |
|---|---|---|---|
| 1 | | | |
| 2 | | 0 | 8 |
| 3 | | 0.1 | 9 |
| 4 | | 0.3 | 10 |
| 5 | | 0.6 | 11 |
| 6 | | 0.8 | 12 |

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## *Representing Probability Distributions -- MORE*

To obtain a random sample from a multinomial distribution we then use the following command:

=VLOOKUP(RAND(),TABLE,2)

Rectangular range of b2..c6

The second column in the defined range.

Note:
Cell range b2 to c 6
has been named TABLE
using the *Insert* | *Name* | *Define*
command in EXCEL

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## Textbook Example

In August, Walton Bookstore must decide how many of next year's nature calendar to order. Each calendar costs the bookstore $7.50 and is sold for $10. After February 1 all unsold calendars are returned to the publisher for a refund of $2.50 per calendar. Walton believes that the number of calendars it can sell by February 1 follows the probability distribution shown below. Walton wants to maximize the expected profit from calendar sales. How many calendars should Walton order?

| Calendars Demanded | Probability |
|---|---|
| 100 | 0.30 |
| 150 | 0.20 |
| 200 | 0.30 |
| 250 | 0.15 |
| 300 | 0.05 |

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## Setting up our spreadsheet:

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | **Simulation of Walton's bookstore** | | | | | |
| 2 | | | | | | |
| 3 | **Cost data** | | | **Demand distribution** | | |
| 4 | Unit cost | $7.50 | | Probability | Cum Prob | Demand |
| 5 | Unit price | $10.00 | | 0.30 | 0.00 | 100 |
| 6 | Unit refund | $2.50 | | 0.20 | 0.30 | 150 |
| 7 | | | | 0.30 | 0.50 | 200 |
| 8 | **Decision variable** | | | 0.15 | 0.80 | 250 |
| 9 | Order quantity | 200 | | 0.05 | 0.95 | 300 |

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## Adding simulation to spreadsheet:

- B13 =RAND()
- C13 =VLOOKUP(B13,$Lookup,2)
- D13 +$B$5*MIN(C13,$B$9)
- E13 +$B$4*$B$9
- F13 +$B$6*MAX($B$9-C13,0)
- G13 +D13-E13+F13

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| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | **Simulation of Walton's bookstore** | | | | | | |
| 2 | | | | | | | |
| 3 | **Cost data** | | | **Demand distribution** | | | |
| 4 | Unit cost | $7.50 | | Probability | Cum Prob | Demand | |
| 5 | Unit price | $10.00 | | 0.30 | 0.00 | 100 | |
| 6 | Unit refund | $2.50 | | 0.20 | 0.30 | 150 | |
| 7 | | | | 0.30 | 0.50 | 200 | |
| 8 | **Decision variable** | | | 0.15 | 0.80 | 250 | |
| 9 | Order quantity | 200 | | 0.05 | 0.95 | 300 | |
| 10 | | | | | | | |
| 11 | **Simulation** | | | | | | |
| 12 | Replication | Random number | Demand | Revenue | Cost | Refund | Profit |
| 13 | 1 | 0.8690 | 250 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |

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## Simulate using: Data | Table

1. Select cells A13 through B62.
2. Click the Data menu.
3. Click Table.
4. In the table dialog box enter cell F1 (or any blank cell) for the Column input cell.
5. Click OK.

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| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | **Simulation of Walton's bookstore** | | | | | | |
| 2 | | | | | | | |
| 3 | **Cost data** | | | **Demand distribution** | | | |
| 4 | Unit cost | $7.50 | | Probability | Cum Prob | Demand | |
| 5 | Unit price | $10.00 | | 0.30 | 0.00 | 100 | |
| 6 | Unit refund | $2.50 | | 0.20 | 0.30 | 150 | |
| 7 | | | | 0.30 | 0.50 | 200 | |
| 8 | **Decision variable** | | | 0.15 | 0.80 | 250 | |
| 9 | Order quantity | 200 | | 0.05 | 0.95 | 300 | |
| 10 | | | | | | | |
| 11 | **Simulation** | | | | | | |
| 12 | Replication | Random number | Demand | Revenue | Cost | Refund | Profit |
| 13 | 1 | 0.0983 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 14 | 2 | 0.1861 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 15 | 3 | 0.6366 | 200 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 16 | 4 | 0.8724 | 250 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 55 | 43 | 0.5176 | 200 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 56 | 44 | 0.4998 | 150 | $1,500.00 | $1,500.00 | $125.00 | $125.00 |
| 57 | 45 | 0.0273 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 58 | 46 | 0.8384 | 250 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 59 | 47 | 0.9720 | 300 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 60 | 48 | 0.1887 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 61 | 49 | 0.6366 | 200 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 62 | 50 | 0.0211 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |

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| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 10 | | | | | | | |
| 11 | **Simulation** | | | | | | |
| 12 | Replication | Random number | Demand | Revenue | Cost | Refund | Profit |
| 13 | 1 | 0.0983 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 14 | 2 | 0.1861 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 15 | 3 | 0.6366 | 200 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 16 | 4 | 0.8724 | 250 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 55 | 43 | 0.5176 | 200 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 56 | 44 | 0.4998 | 150 | $1,500.00 | $1,500.00 | $125.00 | $125.00 |
| 57 | 45 | 0.0273 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 58 | 46 | 0.8384 | 250 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 59 | 47 | 0.9720 | 300 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 60 | 48 | 0.1887 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 61 | 49 | 0.6366 | 200 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 62 | 50 | 0.0211 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 63 | | | | | | AvgProfit | $222.50 |
| 64 | | | | | | StDevProfit | $328.58 |
| 65 | | | | | | MinProfit | ($250.00) |
| 66 | | | | | | MaxProfit | $500.00 |
| 67 | | | | | | | |
| 68 | | | | | | 95% confidence interval for mean | |
| 69 | | | | | | Lower limit | $131.42 |
| 70 | | | | | | Upper limit | $313.58 |

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## Simulation results

| | F | G |
|---|---|---|
| 63 | AvgProfit | $222.50 |
| 64 | StDevProfit | $328.58 |
| 65 | MinProfit | ($250.00) |
| 66 | MaxProfit | $500.00 |
| 67 | | |
| 68 | 95% confidence interval for mean | |
| 69 | Lower limit | $131.42 |
| 70 | Upper limit | $313.58 |

G63 = AVERAGE
G64 = STD DEV
SQRT(N) where n is number of replicates

To find 95% confidence interval (lower limit shown):

=G63-NORMSINV(0.975)*G64/SQRT(50)

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## Using a Data Table

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | **Simulation of Walton's bookstore** | | | | | |
| 2 | | | | | | |
| 3 | **Cost data** | | | **Demand distribution** | | |
| 4 | Unit cost | $7.50 | | Probability | CumProb | Demand |
| 5 | Unit price | $10.00 | | 0.30 | 0.00 | 100 |
| 6 | Unit refund | $2.50 | | 0.20 | 0.30 | 150 |
| 7 | | | | 0.30 | 0.50 | 200 |
| 8 | **Decision variable** | | | 0.15 | 0.80 | 250 |
| 9 | Order quantity | 200 | | 0.05 | 0.95 | 300 |
| 10 | | | | | | |
| 11 | **Simulation** | | | | | |
| 12 | Random number | Demand | Revenue | Cost | Refund | Profit |
| 13 | 0.8136 | 250 | $2,000.00 | $1,500.00 | $0.00 | $500.00 |
| 14 | | | | | | |
| 15 | **Data table for replications, each shows profit from that replication** | | | | | |
| 16 | Replication | Profit | | | | |
| 17 | | $500.00 | | | | |
| 18 | 1 | $500.00 | | | | |
| 19 | 2 | $500.00 | | | | |
| 20 | 3 | ($250.00) | | | | |
| 21 | 4 | $125.00 | | | | |
| 65 | 48 | $500.00 | | | | |
| 66 | 49 | $125.00 | | | | |
| 67 | 50 | $125.00 | | | | |
| 68 | Average | $260.00 | | | | |
| 69 | StDev | $270.63 | | | | |
| 70 | Minimum | ($250.00) | | | | |
| 71 | Maximum | $500.00 | | | | |
| 72 | | | | | | |
| 73 | 95% confidence interval for mean profit | | | | | |
| 74 | Lower limit | $184.99 | | | | |
| 75 | Upper limit | $335.01 | | | | |

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## Two way data table

running simulations at various order quantities:

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | **Simulation of Walton's bookstore** | | | | | |
| 2 | | | | | | |
| 3 | **Cost data** | | | **Demand distribution** | | |
| 4 | Unit cost | $7.50 | | Probability | CumProb | Demand |
| 5 | Unit price | $10.00 | | 0.30 | 0.00 | 100 |
| 6 | Unit refund | $2.50 | | 0.20 | 0.30 | 150 |
| 7 | | | | 0.30 | 0.50 | 200 |
| 8 | **Decision variable** | | | 0.15 | 0.80 | 250 |
| 9 | Order quantity | 200 | | 0.05 | 0.95 | 300 |
| 10 | | | | | | |
| 11 | **Simulation** | | | | | |
| 12 | Random number | Demand | Revenue | Cost | Refund | Profit |
| 13 | 0.2881 | 100 | $1,000.00 | $1,500.00 | $250.00 | ($250.00) |
| 14 | | | | | | |
| 15 | **Data table showing profit for replications with various order quantities** | | | | | |
| 16 | Replication | Order quantity | | | | |
| 17 | ($250.00) | 100 | 150 | 200 | 250 | 300 |
| 18 | 1 | $250.00 | $375.00 | ($250.00) | ($500.00) | ($750.00) |
| 19 | 2 | $250.00 | $375.00 | $500.00 | ($500.00) | ($750.00) |
| 20 | 3 | $250.00 | $0.00 | $500.00 | $625.00 | $0.00 |
| 21 | 4 | $250.00 | $375.00 | $500.00 | ($500.00) | $0.00 |
| 65 | 48 | $250.00 | $0.00 | $125.00 | ($500.00) | ($375.00) |
| 66 | 49 | $250.00 | $375.00 | $500.00 | ($500.00) | ($750.00) |
| 67 | 50 | $250.00 | $375.00 | $125.00 | $250.00 | ($750.00) |
| 68 | Averages | $250.00 | $285.00 | $290.00 | ($57.50) | ($352.50) |

Set to equal “profit” cell

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| Simulation | | | | | |
|---|---|---|---|---|---|
| Random number | Demand | Revenue | Cost | Refund | Profit |
| 0.3179 | 150 | $1,500.00 | $1,500.00 | $125.00 | $125.00 |

**Data table showing profit for replications with various order quantities**

| Replication | Order quantity | | | | |
|---|---|---|---|---|---|
| $125.00 | 100 | 150 | 200 | 250 | 300 |
| 1 | $250.00 | $0.00 | ($250.00) | ($500.00) | ($375.00) |
| 2 | $250.00 | $375.00 | $500.00 | $250.00 | ($750.00) |
| 3 | $250.00 | $375.00 | $500.00 | $250.00 | ($750.00) |
| 4 | $250.00 | $375.00 | ($250.00) | $625.00 | $375.00 |
| 48 | $250.00 | $375.00 | $500.00 | $625.00 | $375.00 |
| 49 | $250.00 | $375.00 | $125.00 | ($500.00) | ($750.00) |
| 50 | $250.00 | $375.00 | $500.00 | ($125.00) | ($375.00) |
| Averages | $250.00 | $270.00 | $162.50 | $107.50 | ($232.50) |

For each of several order quantities this table calculates 50 replications of the profit, based on row 13. When building the data table, cell B9( order quantity) is the "row input" and any blank cell can be used as the "column input."

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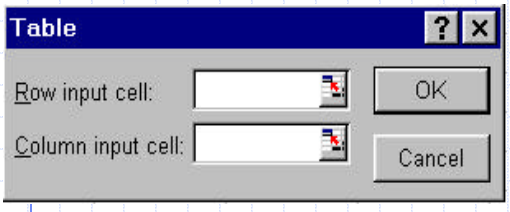
## Two way data table




Note:
B9 --> order quantity cell

1. Select the range A17 through F67.
2. Click the Data menu.
3. Click Table.
4. Enter cell B9 for the row input cell.
5. Enter any blank cell for column input cell.
6. Click OK.

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## In Class Exercise: See end of textbook section for this problem

A sweat shirt supplier is trying to decide how many sweatshirts to print for the upcoming NCAA basketball championships. The final four teams have emerged from the quarterfinal round, and there is now one week left until the semifinals, which are then followed in a couple of days by the finals. Each sweatshirt costs $10 to produce and sells for $25. However, in three weeks any leftover sweatshirts will be put on sale for half price, $12.50. The supplier assumes that the demand for his sweatshirts during the next three weeks (when interest is at its highest) has the distribution shown in table A. The residual demand, after the sweatshirts have been put on sale, has the distribution shown in table B. The supplier, being a profit maximizer, realizes that every sweatshirt sold, even at the sale price, yields a profit. However, he also realizes that any sweatshirt produced but not sold (even at the sale price) must be thrown away, resulting in a $10 loss per sweatshirt. Analyze the supplier's problem with a simulation spreadsheet.

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| Demand distribution at regular price | |
|---|---|
| Demand | Probability |
| 7 | 0.05 |
| 8 | 0.10 |
| 9 | 0.25 |
| 10 | 0.30 |
| 11 | 0.20 |
| 12 | 0.10 |

| Demand distribution at reduced price | |
|---|---|
| Demand | Probability |
| 2 | 0.20 |
| 3 | 0.30 |
| 4 | 0.20 |
| 5 | 0.15 |
| 6 | 0.10 |
| 7 | 0.05 |

NOTE: Demands are in 1000's.

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## Hints:

Hint #1: Set up simulation part as shown below.

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 22 | Original demand | Sale price demand | Number sold at regular price | Number sold at sale price | Number leftover | Profit |

You have to make some comparisons to get these numbers.

Hint #2: this will require a two-way table.
Hint #3: you might limit yourself to quantities ranging from 11,000 to 14,000 sweatshirts in increments of 500.

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