Week 4: Decisions in Settings with High Uncertainty

◆ Session 1 – Decision Trees
  ○ Example: Furniture maker IDEA Chooses a Supplier

◆ Session 2 – Using Simulation within Decision Trees
  ○ Example: More Complex Demand Distributions for IDEA

◆ Session 3 – Using Optimization Together with Simulation
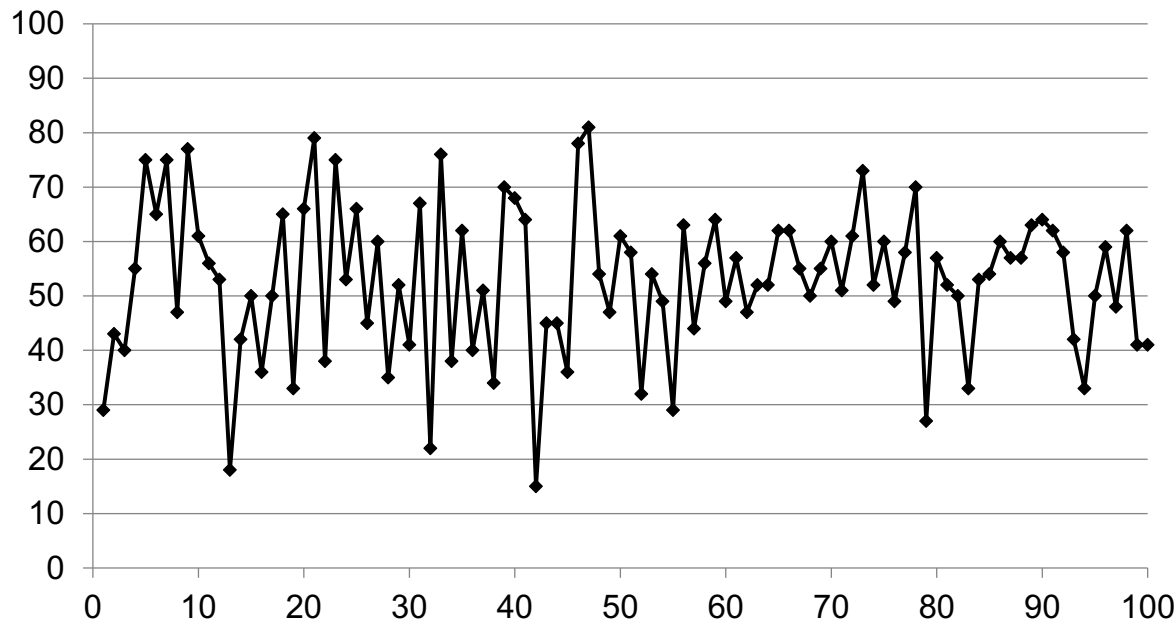 ○ Example: IDEA Chooses Order Quantities

◆ Session 4 – Wrap Up
  ○ Example: Back to the Newsvendor Problem

Remember Senthil's newsvendor problem from week 1

◆ You are selling "wodgets"
  - Unit cost = 3 talers
  - Sales price = 12 talers
  - Salvage value = 0 talers

◆ Historically, demand has been variable, uncertain

◆ How many wodgets, Q, should you order to maximize expected profit?

We know how to find a good order quantity Q

◆ Use the historical data to forecast future demand
  ○ Normally distributed with mean of 52.81 and standard deviation of 15.10

◆ Use the demand forecast to drive a simulation
  ○ If we order Q and demand is D, then profit π = 12 * min{D , Q} – 3 * Q
  ○ For a given Q simulate samples of D and calculate a π for each sample
  ○ Calculate the average of the π's

◆ Use optimization for find an average-profit-maximizing Q for the sample
  ○ Objective to maximize the average profit
  ○ Decision variable is Q
  ○ Constraints on minimum and maximum order quantity

◆ The optimal Q maximizes average profit for the sample
  ○ It's a good estimate of the optimal Q for the demand forecast

Q* ≈ 60 maximizes expected profit for this sample

	A	B	C	D	E	F	G	H
1	Newsvendor Optimization.xlsx							
2								
3	Sales Price =		12					
4	Unit Cost =		3					
5	Order Quantity =		**59.5**					
6								
7								
8		Simulated	Sales	Unit	Total			
9	Sample	Value	Revenue	Cost	Profit			
10	1	35.4	424.5	178.6	245.9			
11	2	15.3	183.7	178.6	5.1			
12	3	48.6	582.8	178.6	404.2			
13	4	43.4	521.2	178.6	342.6			
14	5	60.9	714.4	178.6	535.8			
15	6	41.9	503.1	178.6	324.5			
16	7	51.5	618.3	178.6	439.7			
17	8	62.9	714.4	178.6	535.8			
58	49	65.6	714.4	178.6	535.8			
59	50	52.0	624.3	178.6	445.7			
60								
61				Average =	401.7			
62				Standard Deviation =	157.9			

Decision variable

=$C$3*MIN(B10,$C$5)

=$C$4*$C$5

=C10-D10

Maximization Objective

=AVERAGE(E10:E1009)

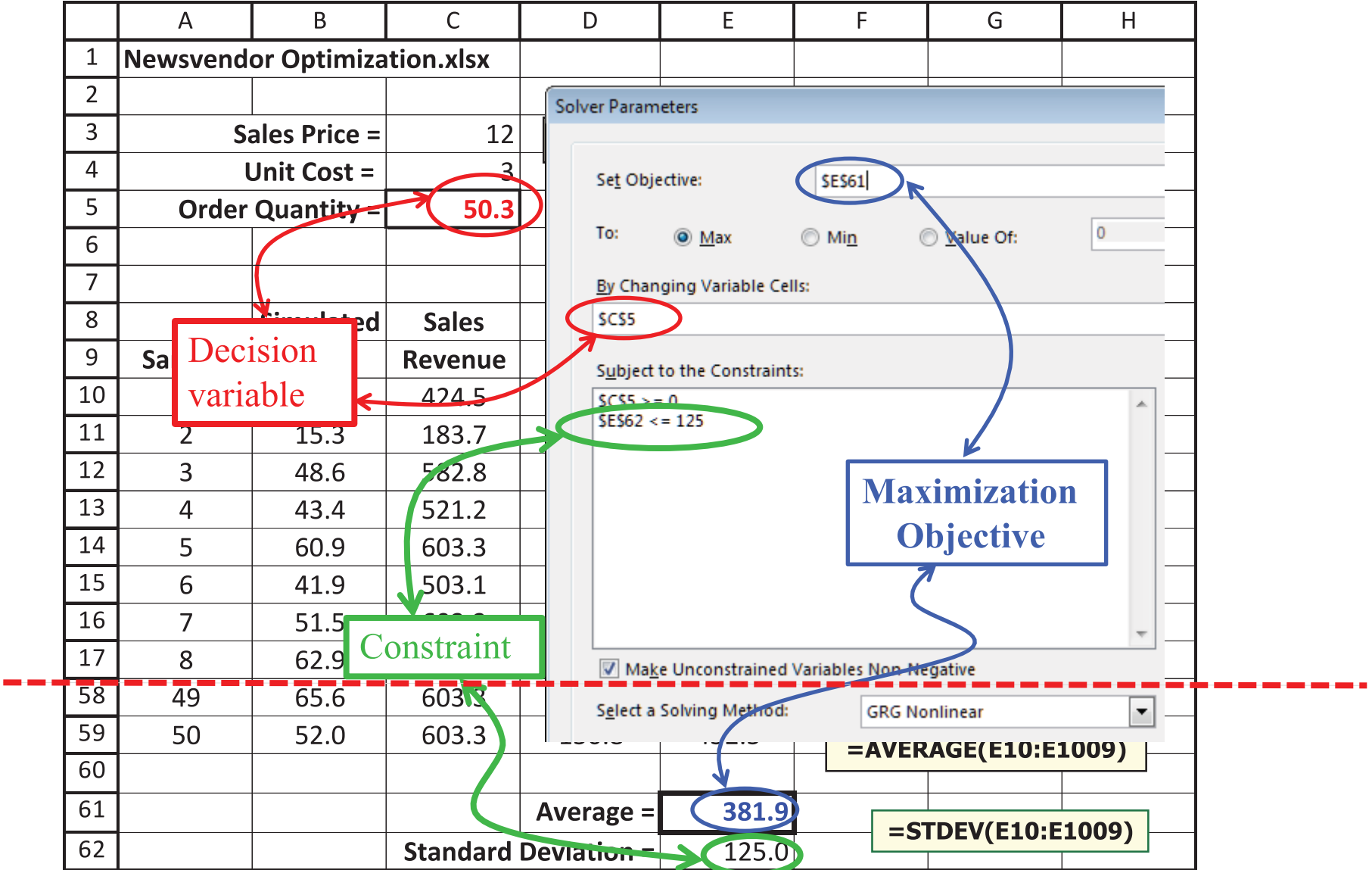=STDEV(E10:E1009)

We can also include constraints on risk

◆ Recall Sergei's session on risk and reward
  ❍ Often decision makers must trade off risk and reward
  ❍ A common measure of reward is expected value…it's "risk neutral"
  ❍ One common measure of risk (of many) is the standard deviation

◆ Suppose we want to limit the newsvendor's risk
  ❍ E.g., standard deviation of the profit should be no more than 125 talers

◆ We can update our optimization problem to limit that risk
  ❍ Use Excel to calculate the standard deviation of the profit
  ❍ Add a constraint that limits the standard deviation for any Q

◆ Note: the standard deviation function is also not linear
  ❍ But it is "quadratic" which is a well-behaved kind of nonlinear function
  ❍ For example, see J. R. Evans, *Business Analytics*, Pearson, 2013.

For standard deviation $\leq$ 125 on Q* $\approx$ 50

	A	B	C	D	E	F	G	H
1	**Newsvendor Optimization.xlsx**							
2								
3	**Sales Price =**		12					
4	**Unit Cost =**		3					
5	**Order Quantity =**		**50.3**					
6								
7								
8		**Simulated**	**Sales**					
9	**Sa**		**Revenue**					
10			424.5					
11	2	15.3	183.7					
12	3	48.6	582.8					
13	4	43.4	521.2					
14	5	60.9	603.3					
15	6	41.9	503.1					
16	7	51.5						
17	8	62.9						
58	49	65.6	603.3					
59	50	52.0	603.3					
60								
61			**Average =**		**381.9**				
62			**Standard Deviation =**		125.0				

Decision variable

Constraint

Maximization Objective

Solver Parameters

Set Objective: $E$61

To: ⦿ Max ◯ Min ◯ Value Of: 0

By Changing Variable Cells:
$C$5

Subject to the Constraints:
$C$5 >= 0
$E$62 <= 125

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: GRG Nonlinear

=AVERAGE(E10:E1009)

=STDEV(E10:E1009)

Wrap-up for Week 4 Session 4

◆ We came back to the newsvendor, a fundamental problem in operations
  ❍ Given the price, cost, and a demand history choose a good order quantity Q

◆ We used the demand forecast from week 1, along with simulation and optimization from weeks 2 and 3 to find a good Q

◆ With these tools, finding an effective Q was easy
  ❍ Simulate a large number of demands
  ❍ Optimize to find a Q that maximizes average profit for the sample
  ❍ Use the optimal Q for the sample as an estimate of the optimal Q

◆ Adding a constraint on the standard deviation of the profit was also easy

◆ Two caveats
  ❍ The problem's "min {D,Q}" is not linear – see the optional advanced session
  ❍ The standard deviation is also non-linear – but that's not a problem