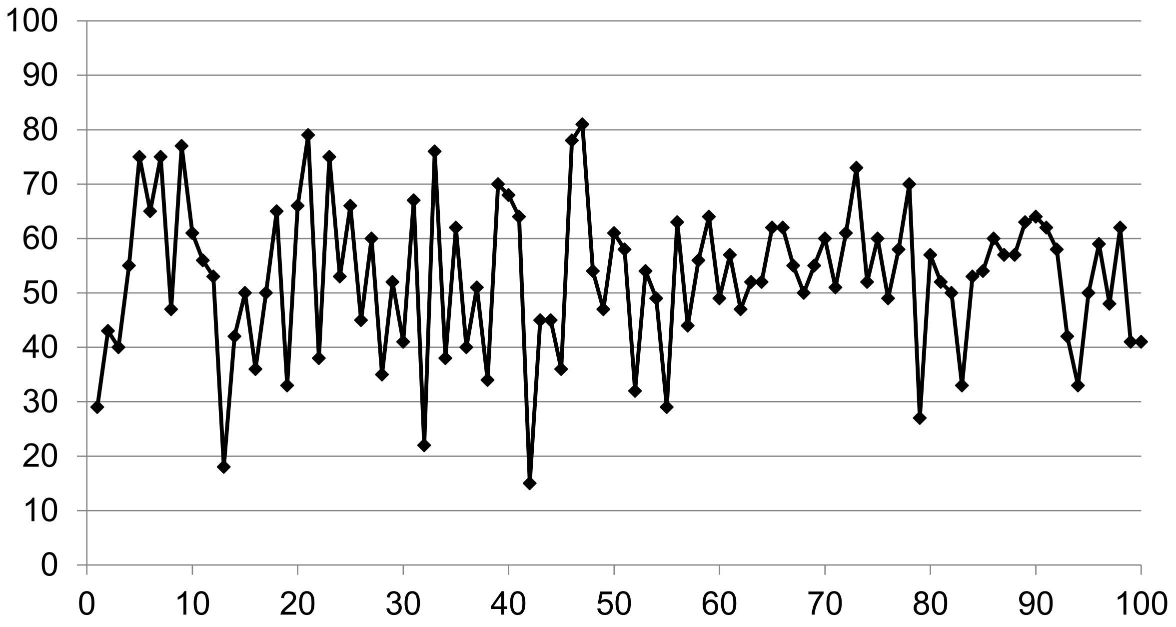
Week 4: Decisions in Settings with High Uncertainty

- 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 $\pi = 12 * \min\{D, Q\} - 3 * Q$
  - 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

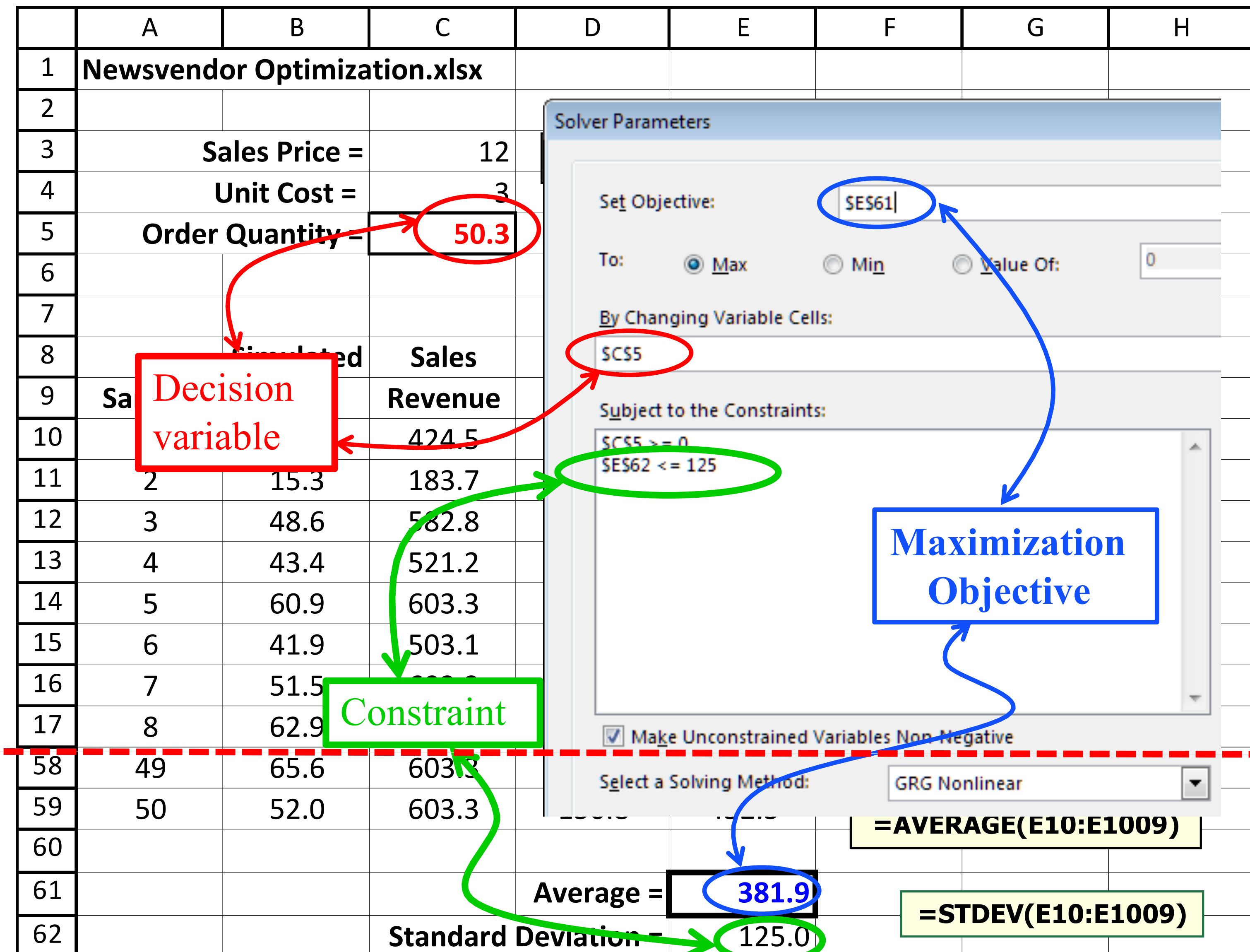
`=AVERAGE(E10:E1009)`

`=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 <u>is</u> "quadratic" which is a well-behaved kind of nonlinear function
  - For example, see J. R. Evans, *Business Analytics*, Pearson, 2013.

For standard deviation ≤ 125 on Q* ≈ 50



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