

# IS602 – Spreadsheets Modeling for Decision Making

## #2. Spreadsheet Engineering

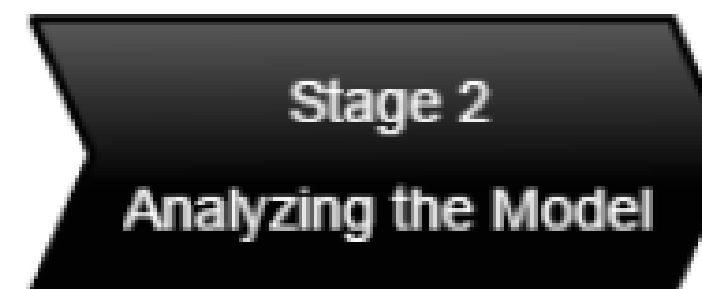
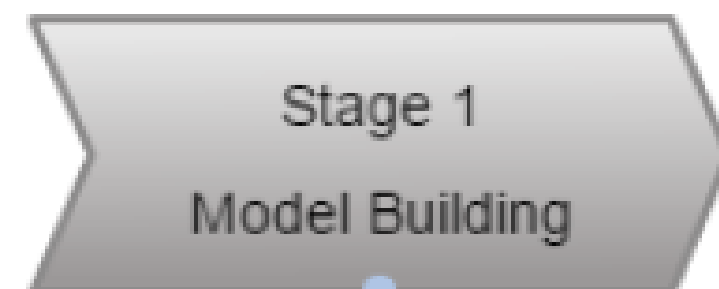
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**nlma@smu.edu.sg**

# Learning Objectives

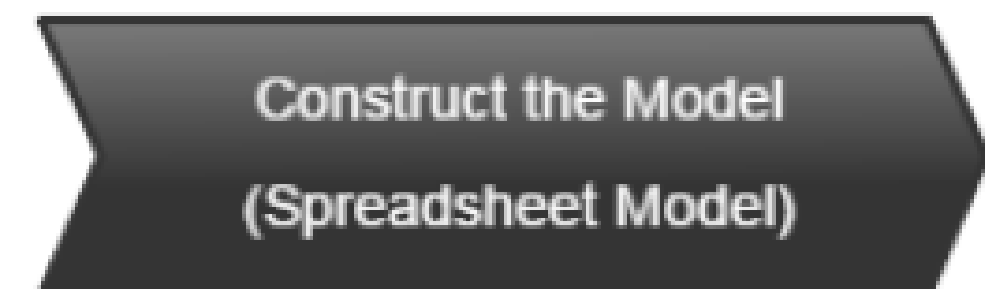
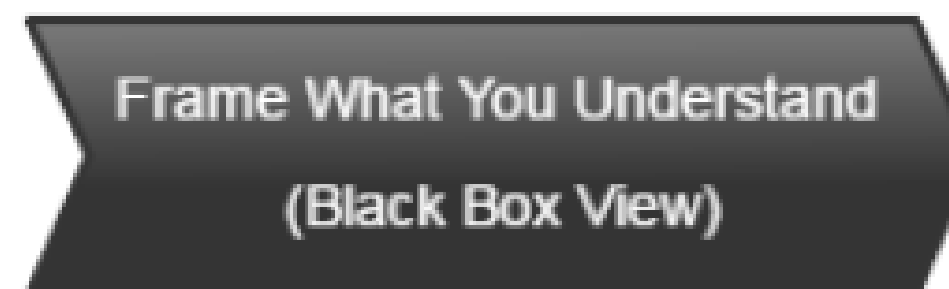
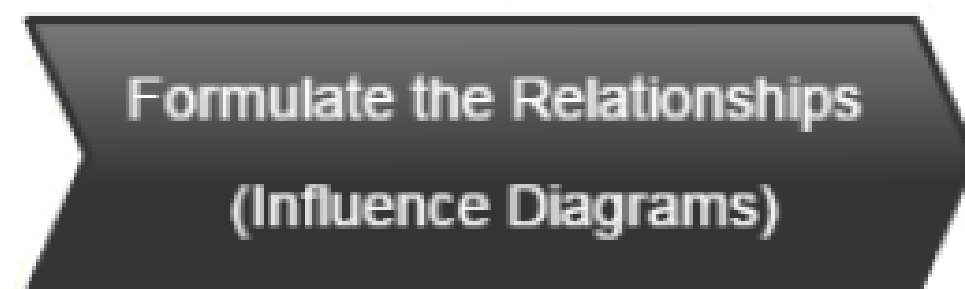
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- Understand Model Building using 2 schematic models
  - Influence Diagram
  - Blackbox Model
- Create Spreadsheet Model based on the 2 schematic models
  - Input, Intermediate, Output
- Analyze the Model
  - What-if Scenarios
  - Sensitivity Analysis and Trade-off Analysis
- Exercise: Inkjet Printer

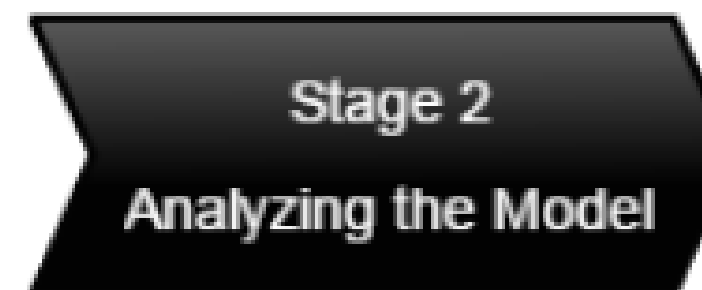
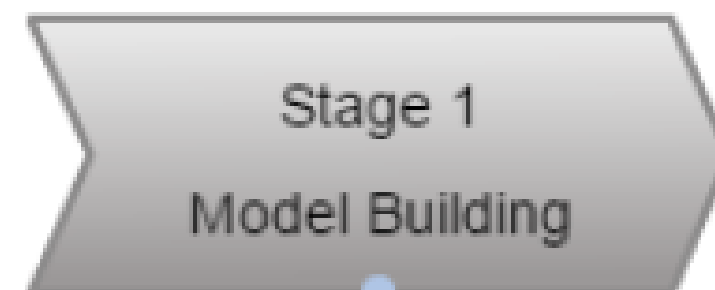
# Overview of Modeling



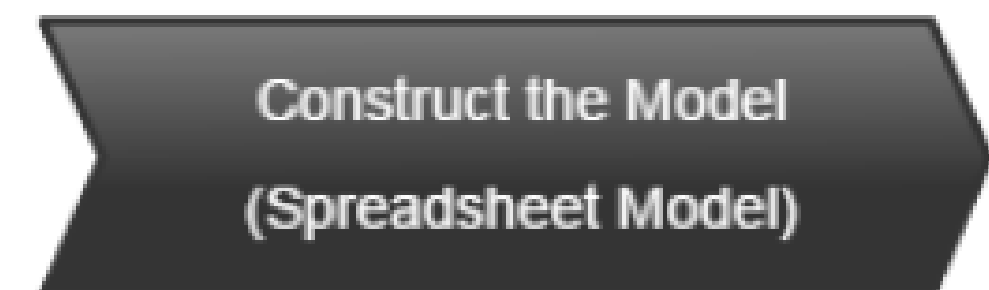
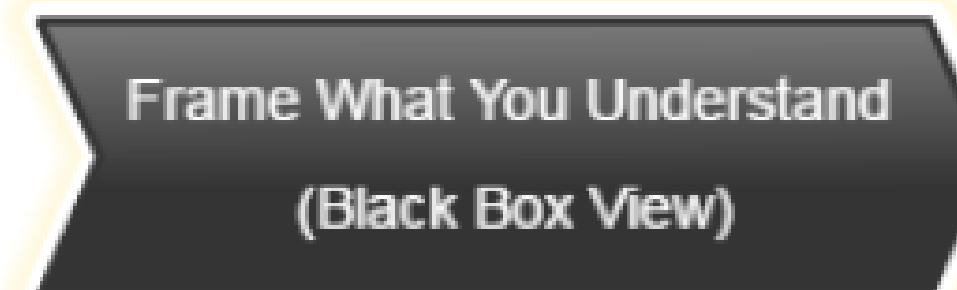
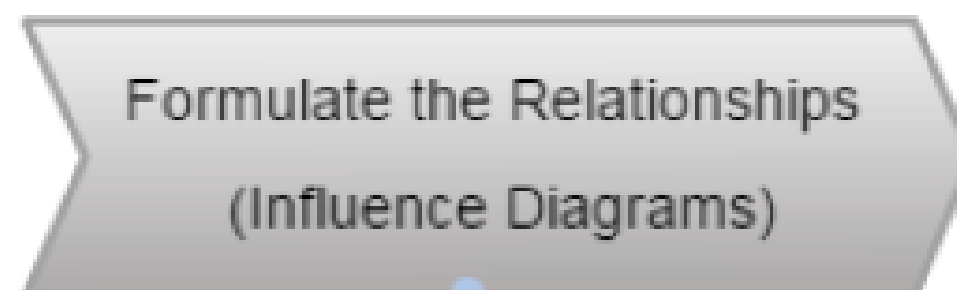
Basic steps to develop an effective spreadsheet model:



# Influence Diagram

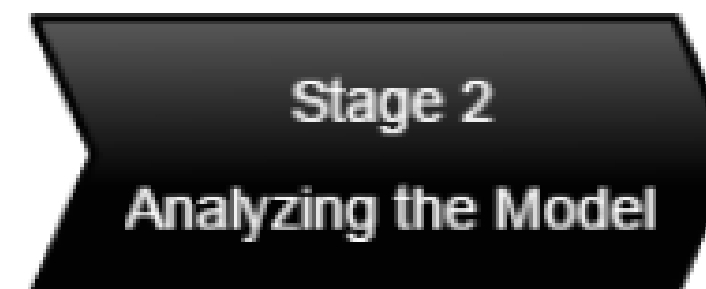
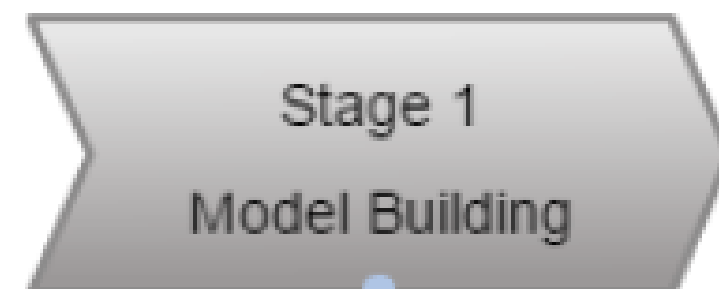


Basic steps to develop an effective spreadsheet model:

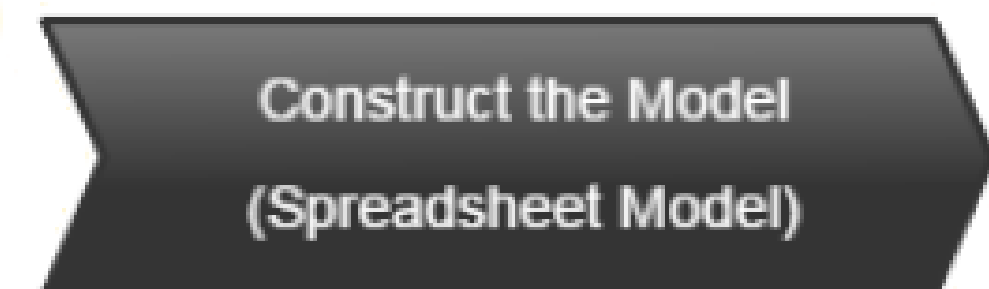
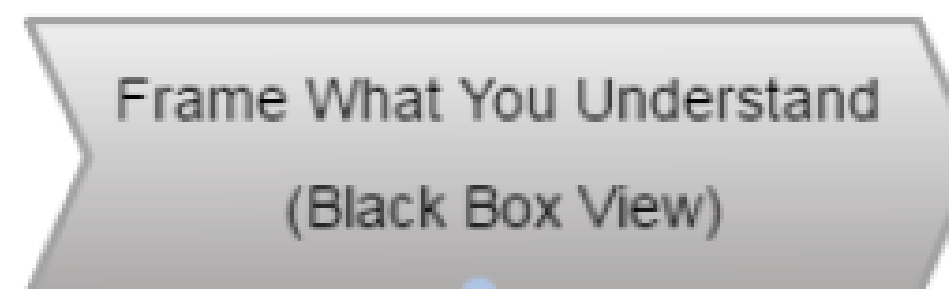
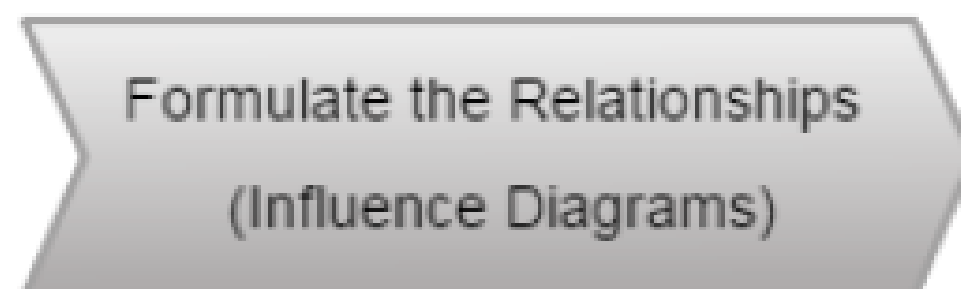


- Draw a picture (**influence diagram**) to better understand the situation.
- Identify the **decision variables**, the **parameters** or **uncontrollable inputs**, and the **outputs**.
- Define the **logic** necessary to **transform the inputs into the outputs**.
- Determine the **formulas** relating the inputs to the intermediate calculations and outputs.

# Blackbox Model

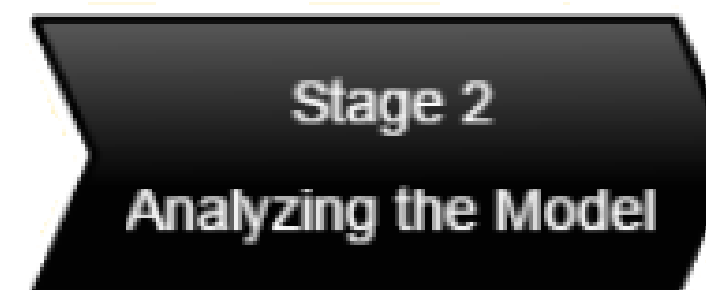


Basic steps to develop an effective spreadsheet model:

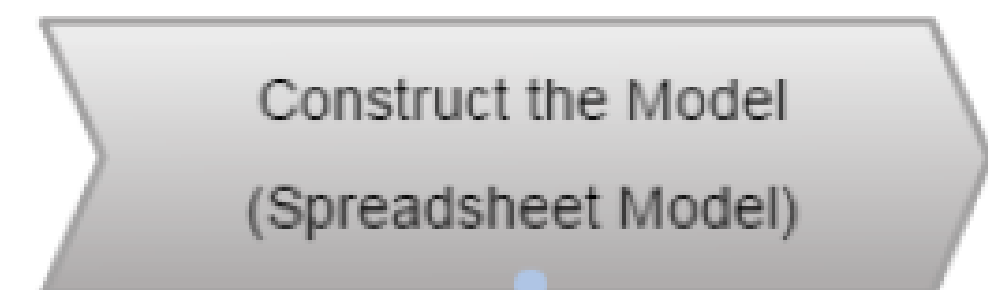
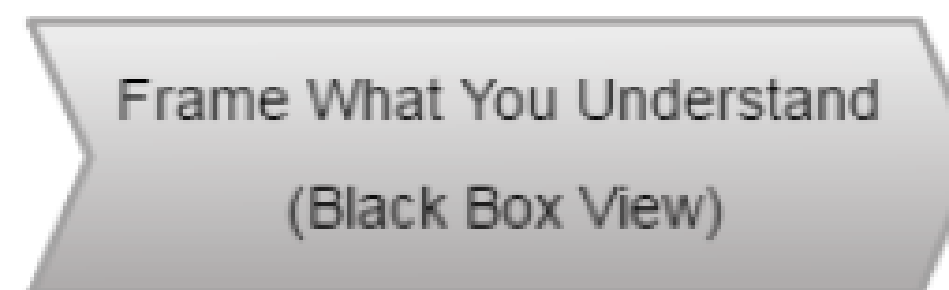
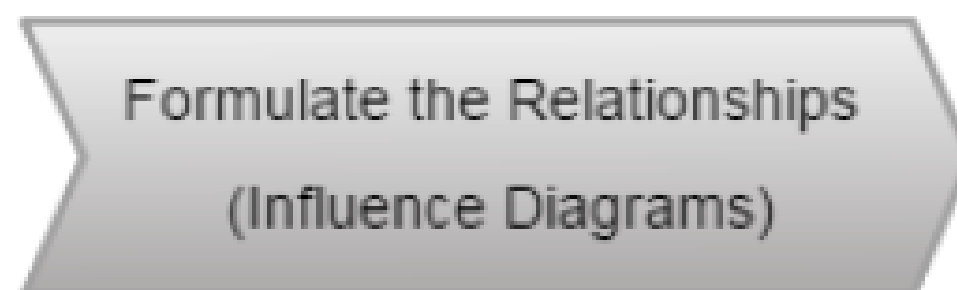


- Draw the **black box model** to determine where the inputs, intermediate calculations, and outputs will go.
- **Highlight** the **key inputs** and **outputs** to make the model easier to use for what-if analysis.

# Construct the Model



Basic steps to develop an effective spreadsheet model:



- Create the **spreadsheet model** and test it using **trial values**.
- Verify the results by hand, if possible.

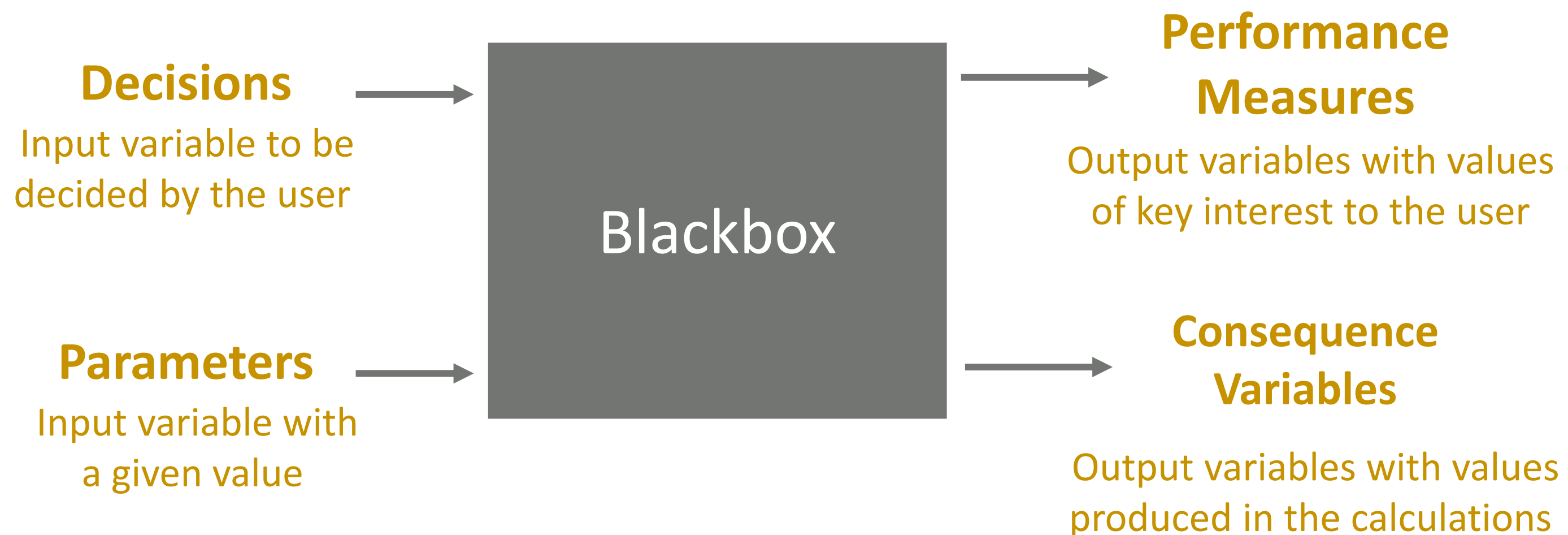
*Note: Calculate the results manually, either with or without the help of a calculator, using some test input values to confirm that the model is giving the right answer. If you have broken down the intermediate calculations into relatively simple formulas, this step is much easier.*

# Influence Diagram

- Influence diagram
  - Pictures the connection between the model's exogenous variables (known and given input variables) with the performance measure (output)
- Steps in building an influence diagrams
  - Start with the performance measure
  - Decompose the performance measure into 2 or more intermediate variables that combine mathematically to define the performance measure
  - Further decompose each intermediate variables into more intermediate variables until the input decision variable is defined
- For example – To determine the profit by setting price
  - Start with “Profit” and define intermediate variables until the “Price” is defined. Intermediate variables will include demand, revenue, cost etc.

# Blackbox Model

- Blackbox model
  - A simple model to summarize the input variables, output variables and logic within the blackbox
    - Decisions (Controllable input)
    - Parameters (Uncontrollable input)
    - Performance Measures (Interested output)
    - Consequence Variables (Calculated output)





# Inkjet Printer Exercise

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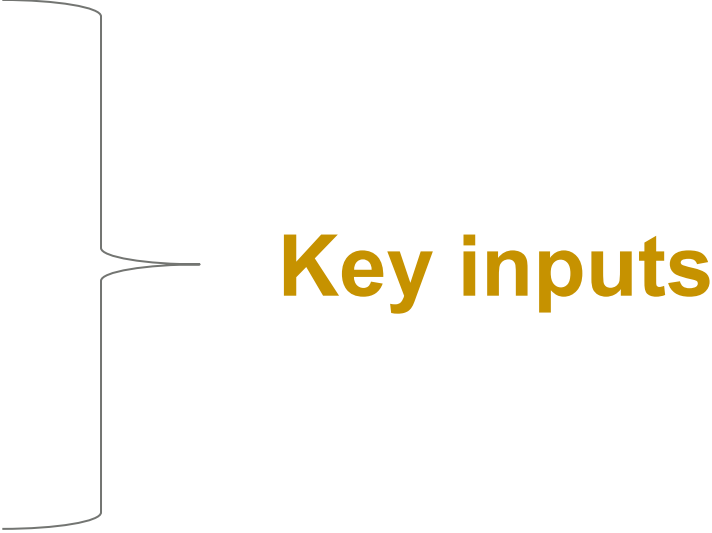
- Construct the model
- Analysis
  - Trade-off analysis
  - Sensitivity analysis
  - Breakeven analysis
- Functions
  - Goal Seek
  - Solver
  - Format Trendline
  - IF, MAX, MIN

# Inkjet Printer Exercise

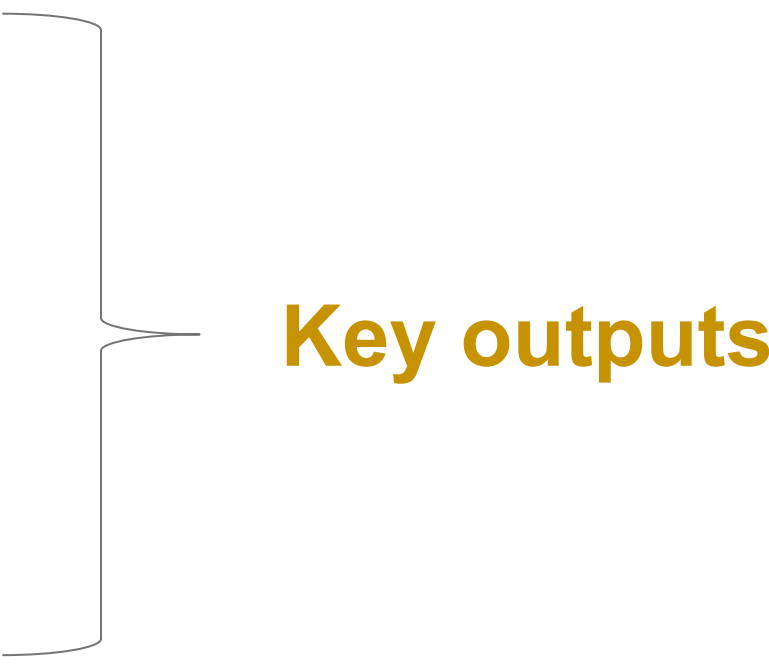
## “Bait & Hook” Business Strategy

- The inkjet printer business had adopted this strategy, offering the basic printer product at a very low (possibly below cost) price but charging a highly marked-up price for their proprietary ink cartridges.
- The setting of printer and ink cartridges prices must therefore be closely linked as they affect the overall profitability of the printer company.
- In this exercise,
  - We build basic approximate relationship between printer’s demand and its price, and relationship between printer and ink cartridge sales.
  - We further illustrate the tradeoff between the relative pricing of the printer and its ink cartridges and their impact on the management indicators of revenue, cost and profit, with an initial objective to maximize profit for the company.
  - A sensitivity analysis is also done on the demand-price slope and cartridge-to-printer projected sales ratio.

# Influence Diagram

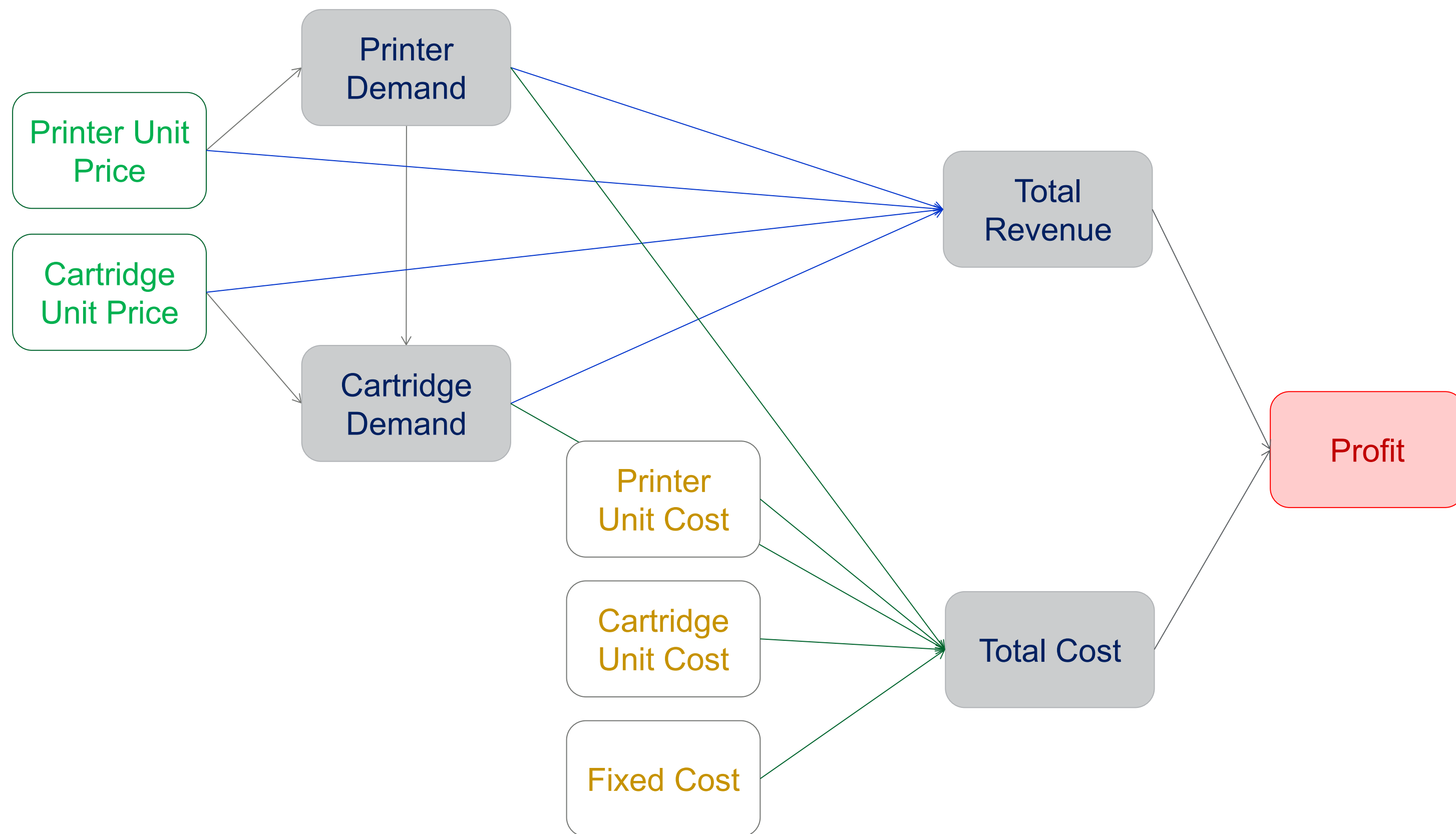
- To help determine the overall profit in selling both printers and ink cartridges, we need a basic model that combines the printer and ink cartridge pricing together.
- Key variables
  - Printer unit cost
  - Printer unit price
  - Cartridge unit cost
  - Cartridge unit price

**Key inputs**

  - Printer Demand
  - Cartridge Demand
  - Total cost
  - Total revenue
  - Profits

**Key outputs**

# Influence Diagram



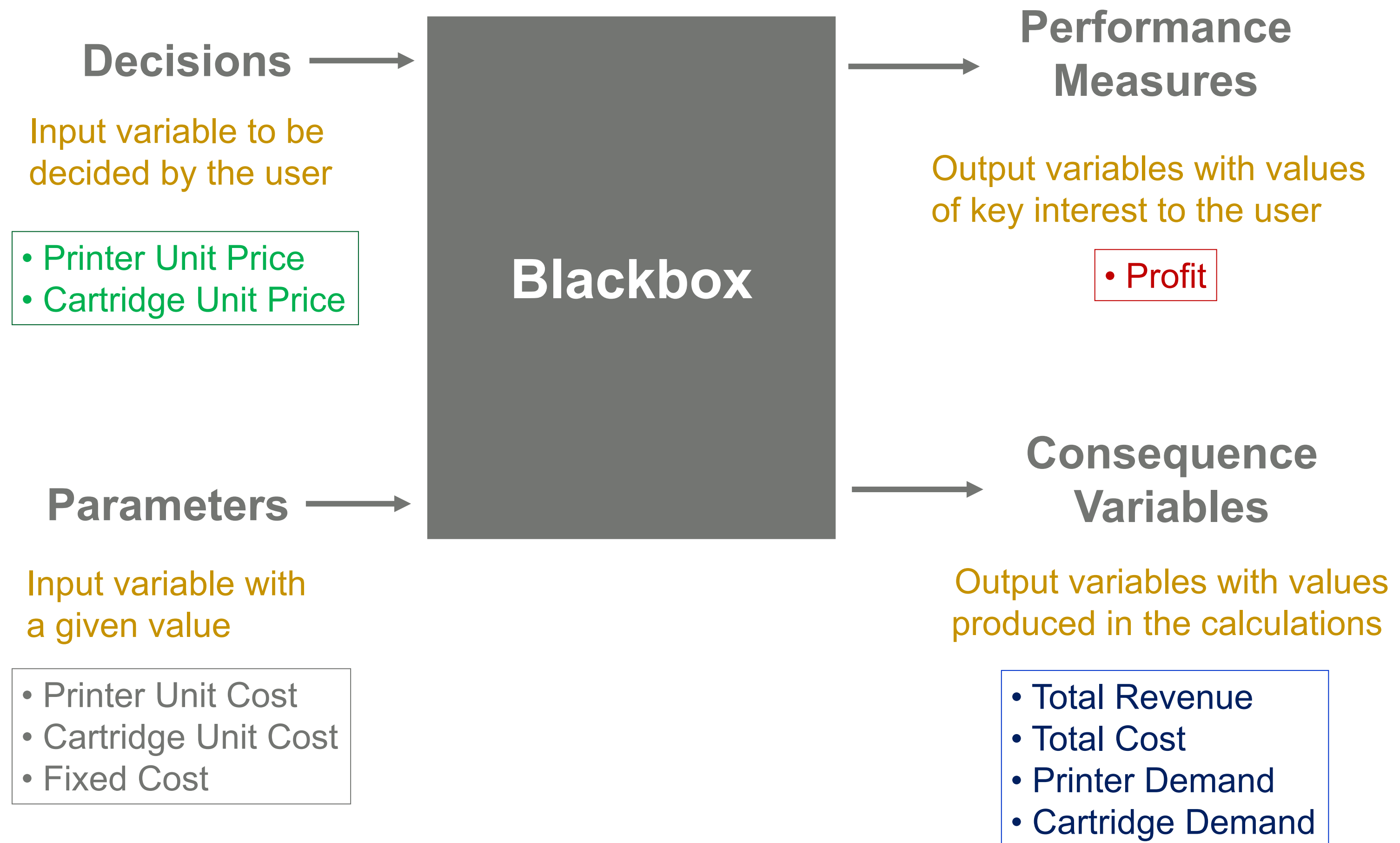
Parameters

Decisions

Performance  
Measure

Consequence  
Variables

# Blackbox Model



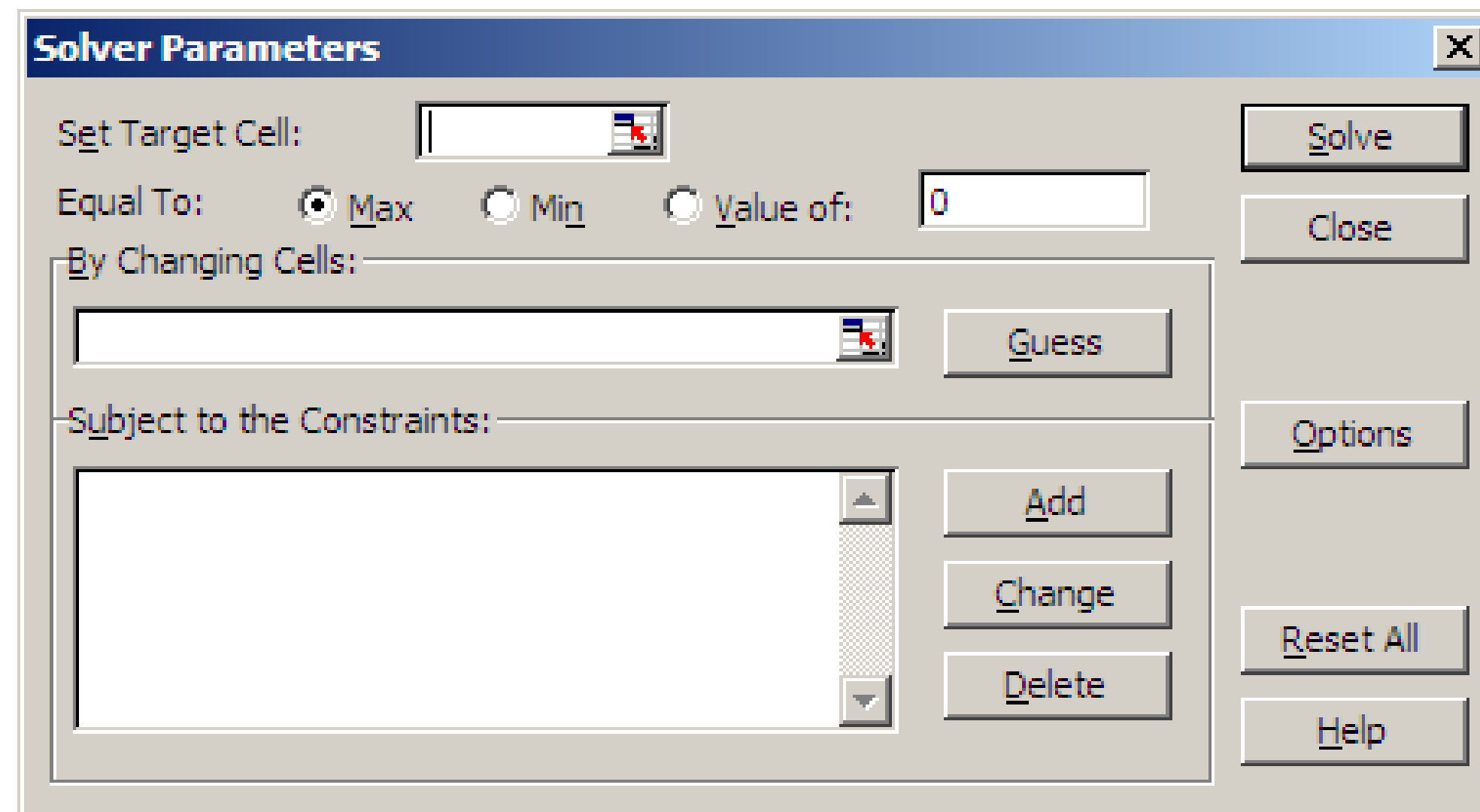
- An Excel tool that finds the input needed in one cell to arrive at the desired result in another cell
- It is part of a suite of commands → what-if analysis tools
- It is used when you know the desired result of a single formula, but not the input value the formula needs to determine the result
- Basically, goal seeking is the ability to calculate backward to obtain an input that would result in a given output.

- It is part of a suite of commands → what-if analysis tools
- It is a program that searches for the optimal solution of a problem involving several variables
- You can find an optimal (maximum or minimum) value for a formula in one cell (objective cell), subject to constraints, on the values of other formula cells in a worksheet
- Solver works with a group of cells, decision variable cells, that participate in computing the formulas in the objective and constraint cells
- Solver adjusts the values in the decision variable cells to satisfy the limits on the constraint cells and produces the result you want for the objective cell



# Optimal Printer Price

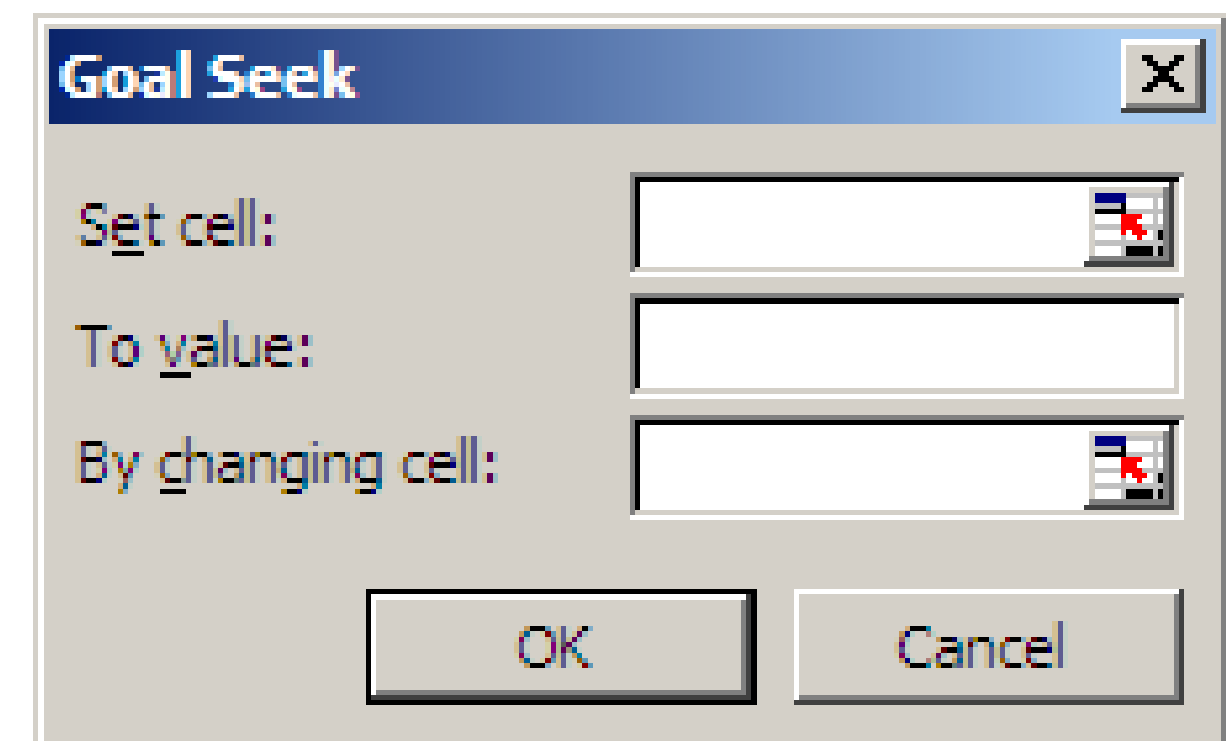
- What is the best printer price to set?
  - ANSWER: Infinity!! Because there is no relationship between demand and price. So, price can go as high as possible, while demand does not decrease.
- Solver to find optimal printer price
  - Target cell = Profit (C27)
  - Equal to = MAX
  - By changing cell = Printer price (C5)





# Break-even Price

- Solver to find break-even price
  - Target cell = Profit (C27)
  - Equal to Value of = 0
  - By changing cell = Printer price (C5)
- Goal Seek to find break-even price
  - Set cell = Profit (C27)
  - To Value = 0
  - By changing = Printer price (C5)



Goal Seek cannot “maximize” or “minimize”.

It can only change ONE input cell value to ensure that the target cell reaches a target value.

# Price-Demand Relationship

- At printer price = \$0, demand = 10,000 units
- For every \$10 increase in price, demand decreases by 600 units.
- At printer price = \$250, demand = 0

Y-intercept  
↓

$$C10 = 10 - 0.6 * \underbrace{(B10 - \$B\$9) / 10}_{\text{\% increase in price}}$$

$\underbrace{\hspace{10em}}_{\text{reduction in demand}}$

Price-demand  
 $y = -0.06x + 10$

where,  
 $y$  = printer demand  
 $x$  = printer price

# Relationship between Printer & Cartridge Sales

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- Price of cartridge cannot be set too high, otherwise no one will buy the printer
- We set the maximum ratio between their prices, e.g.  $2/3$ 
  - This ratio will determine the demand for printer by comparing the prices of cartridge to printer, where both prices are input.
  - Alternatively, we can use this ratio to price the cartridge based on a given printer price. Once both prices are set, we can then set the demand for printer.
- We also set the number of cartridges sold for every printer sold, e.g. 6. This ratio will determine the demand for cartridges based on printer demand.

# Trade-off Analysis

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- Trade-off analysis – is used when a decision variable value (e.g. printer price) is changed, to examine how performance measures (e.g. profit, cost, revenue) "tradeoff" against each other.
- From the trade-off analysis chart, we can easily see,
  - Optimal price setting
  - Break-even price
- Or we can use Solver or Goal Seek

# Sensitivity Analysis

- Sensitivity analysis – is used when uncontrollable parameter values (e.g. slope of printer price-demand curve) are changed to examine how "sensitive" performance measures (e.g. profit) are to the parameter changes.
- Data Table
  - 2 uncontrollable parameters – demand curve slope and number of cartridges per printer sold
  - Results of total profit are tabulated in the table
- Conclusion: Profit change is more sensitive to demand slope change at higher number of cartridges per printer sold. Model is more robust at lower number of cartridges per printer sold.