Analytics in Practice: Quick Vignette

Supply Chain Optimization

- The purpose of a well-designed supply chain is to deliver the right products to customers in a cost-effective and timely fashion.
- *Supply Chain Network Optimization* is a strategic planning process whose purpose is to determine or improve:
  - the structure of the supply chain
  - the location of facilities
  - the sizing of facilities
  - the sourcing and distribution flows
- Examples where supply chain network design is performed:
  - Expansion into a new market
  - Launching a new product
  - Evaluating mergers and acquisitions
  - Responding to supply, demand, or distribution disruptions
  - Responding to cost, demand, or other economic realities
  - Responding to new regulations
  - Simply evolving to adapt to changes in the business environment
- **Optimization is a critical success factor in supply chain design and operation.**

Newspaper Distribution*

- Newspapers are typically distributed through a two-level supply chain

Printing plants → Distribution Depots → Delivery Routes

- A larger newspaper/media company had the opportunity to buy distribution assets (a set of distribution depots and associated paper delivery routes) and needed to determine how much to bid for the assets

- To determine the maximum bid price, the newspaper wanted to understand the cost savings from combining the new depots/routes with its existing supply chain

*Simplified version of a problem from my professional experience

Newspaper Distribution

- This is a supply chain network optimization problem!
- Decision variables: which depots and routes to use
- Constraints
  - Each newspaper subscriber has to be on at least one route
  - A route can be used only if its associated depot is operational
- Objective function: Minimize Cost of Newspaper Delivery*
  - Each depot (current or new) has a fixed monthly cost of ongoing operation if we use it
  - Each paper delivery route has a variable monthly cost depending on the length of the route

*simplified version

Newspaper Distribution

Integer Optimization Approach

- Decision Variables: A binary decision variable $\mathbf{x_D}$ for each depot D and binary decision variable $\mathbf{y_R}$ for each route R

- Constraints
  - Each newspaper subscriber has to be on at least one route
    - For each subscriber, identify the routes that include that subscriber i.e. let's say routes 1, 4, 7 and 8 include that subscriber's address. Then, the constraint is:
      - $\mathbf{y_1} + \mathbf{y_4} + \mathbf{y_7} + \mathbf{y_8} \geq 1$
  - A route can be used only if its associated depot is operational
    - For each route-depot combination: route binary variable <= depot binary variable
      - $\mathbf{y_R} \leq \mathbf{x_D}$

- Objective function: Minimize Cost of Newspaper Delivery
  - Each depot (current or new) has a fixed monthly cost $\mathbf{C_D}$ of ongoing operation if we use it
  - Each delivery route has a variable monthly cost $\mathbf{L_R}$ depending on the length of the route

Total Delivery Cost = $\sum_{all\ depots} \mathbf{C_D x_D}$ + + $\sum_{all\ routes} \mathbf{L_R y_R}$

Newspaper Distribution

- By solving this problem and comparing the cost of the optimal solution with the current delivery cost, we estimated the incremental cost savings IF we owned the new depots and routes.
- These savings helped inform the maximum price we would want to pay for the distribution assets

Key Themes

- Optimization models, especially those utilizing **binary variables**, are **extraordinarily applicable**.

- We have seen several applications where optimization has made significant **business impact**

- But equally important, **optimization** is:
    - A framework for **structuring** one's thinking about decisions
    - A **bridge** from data and predictive models to decisions
    - A must-have **fluency** for **analytics bilinguals** (like you!)

What’s Next

- *Today:* Deliverable #8 (the last one – yay!) will be posted today, due only on December 3rd
- *Thursday*: Deliverable #7 due
- *Friday*: Recitation on Discrete Optimization
- 1-on-1 Meetings
  - *Please book via https://calendly.com/ramamit*
  - *I have added more Calendly slots. If the Calendly times don’t work, please email my assistant Laura (brentrup@mit.edu) to find a time.*