Modeling Beyond the Classroom: Linking Students and Industry

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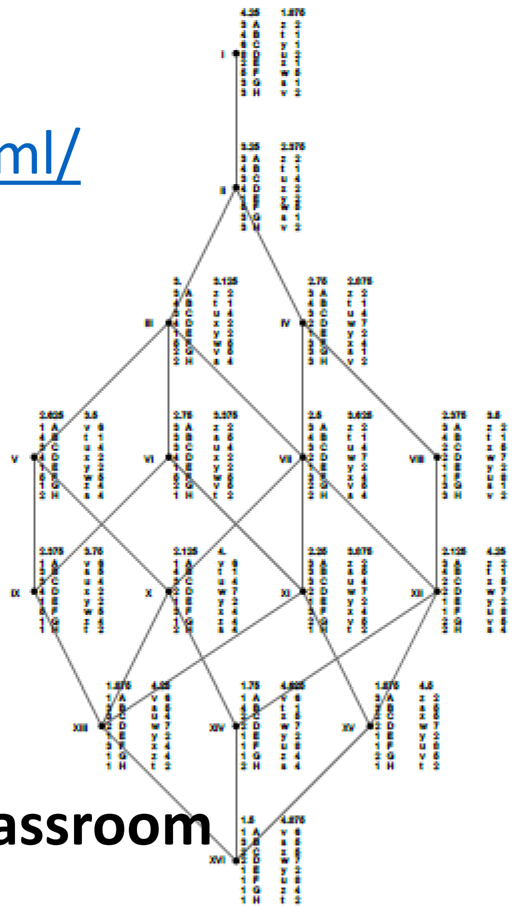
https://web.williams.edu/Mathematics/sjmiller/public_html/



COMAP Contributed Paper Session:

Integrating Modeling into Established Courses

Joint Math Meetings: Boston: Jan 7, 2023

Integrating Math Modeling and Interdisciplinarity into Your Classroom

GOALS:

- Describe Operations Research Class:
  https://web.williams.edu/Mathematics/sjmiller/public_html/377Fa16/index.htm
  https://web.williams.edu/Mathematics/sjmiller/public_html/317Fa22/index.htm

- Discuss Projects

Main Topic: Optimization: Linear Programming.

Objectives

- Obviously learn linear programming.
- Emphasize techniques / asking the right questions.
- Model problems and analyze model.
- Elegant solutions vs brute force.
- Apply to real world problems.
- Writing textbook for AMS.

Board of Trustees of Former Students (with jobs!)

Non-standard homework: Write a letter of recommendation for someone in the class.

Types of Problems

- Diet problem.
- Banking (asset allocation).
- Scheduling (movies, airlines, TSP, MLB).
- Elimination numbers. (especially 2004)
- Sphere packing....

My (applied) experiences

- Marketing: parameters for linear programming (SilverScreener).
- Data integrity: detecting fraud with Benford's Law (IRS, Iranian elections).
- Sabermetrics: Pythagorean Won-Loss Theorem, court case.
- Wall Street consulting.

Inefficiencies from Location

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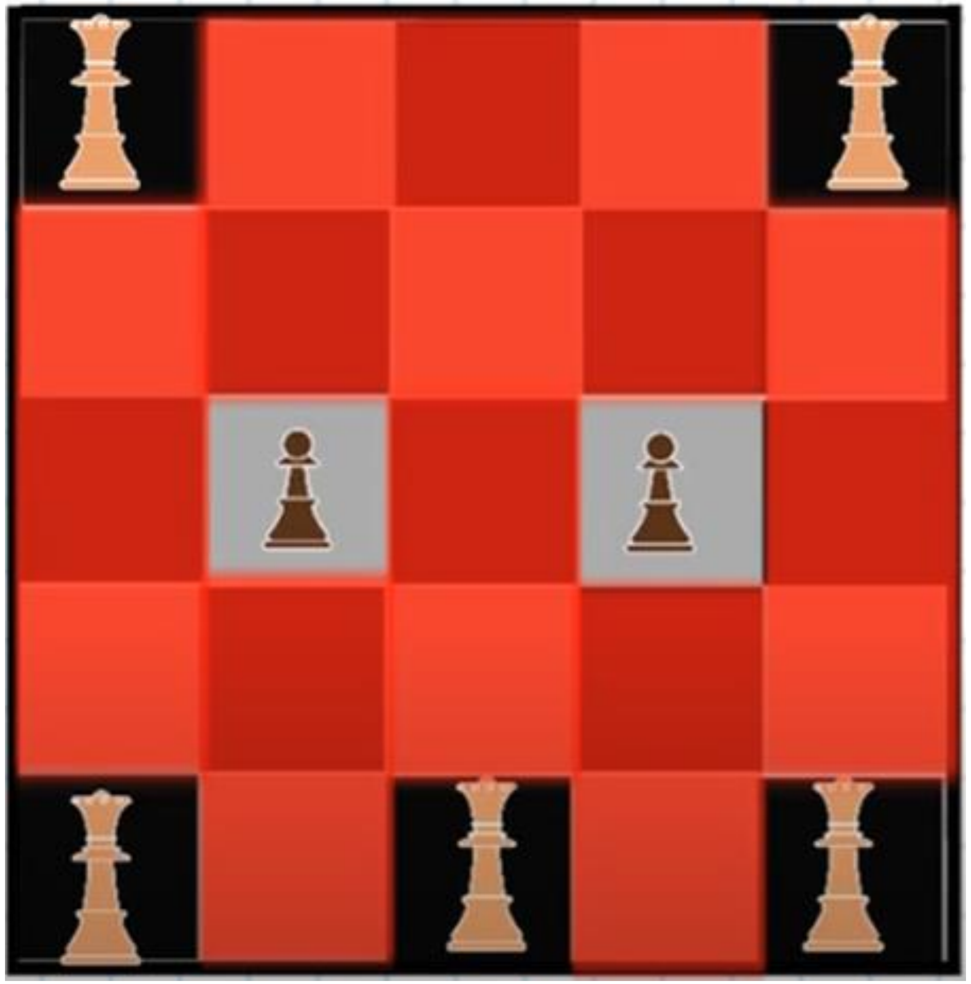
SCHLESWIGLAND
LÜBECK
FUHLSBÜTTEL
FINKENWERDER
FASSBERG
BRITISH
RUSSIAN
WUNSTORF
CELLE
Berlin
BÜCKEBURG
ZONE
ZONE
WIESBADEN
Airlift Base
Support Base
Zonal Boundary
Air Corridor
RHEIN-MAIN
FRENCH
AMERICAN
ZONE
ERDING
ZONE
OBERPFAFFENHOFEN
N
0 50 MILES
0 80 KM
KAUFBEUREN



Student Projects:

- Medical Industry (minimizing return visits)
- Baseball lawsuits
- Scheduling (competitions, schools, TAS)
- Optimizing (resource allocation, cutting)
- Image Processing

Framework

Real World Challenge: Need to assign \$3,500,000 to three schools (LES, WES, MtG).

- Pre-regionalization know how much state gives each; post regionalization only know sum.
- State has formula, lots of variables, secret.

What is the goal? How do we accomplish it?

Objectives

- Fair formula that predicts well.
- Transparent, seems fair.
- Can be explained.

Solution

Solution: Method of Least Squares / Linear Regression.

Inputs: Population of Schools (LES(pop), WES(pop), MtG(pop)), Assessment of Towns (EQV(L), EQV(W)).

Formula: If $\overrightarrow{y} = \mathbf{X}\overrightarrow{\beta}$ then

$$\overrightarrow{\beta} = \left(\mathbf{X}^{\mathrm{T}}\mathbf{X}\right)^{-1}\mathbf{X}^{\mathrm{T}}\overrightarrow{y}.$$

What properties do we want the solution to have?

Properties of Solution

- Want solution to exist – will it?
- Want values to be between 0 and 1 – will it?
- Want values to be stable under small changes – will it?
- Want the sum of the three percentages to add to 1 – will it?

THANK YOU!