ADS4293 LAB11

Chapter 17: Optimization

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LAB SETUP

- Submission:
  - Submit your **Excel file** on Brightspace (Owl)

QUESTION 1

17. A restaurant in New England is best known for its creamy chowder soups. The two most popular soups that sell out every day are New England clam chowder and seafood chowder. The restaurant owner uses her great-grandmother's secret recipes to make all of her dishes, and she prepares all of the ingredients herself every morning. After the ingredients are prepared, one of her trusted sous chefs cooks the chowders by strictly following her precise instructions. For each gallon of the New England clam chowder, she spends 17 minutes to prepare the ingredients, and the sous chef spends 21 minutes to cook the soup on the stove. Each gallon of the seafood chowder takes about 20 minutes to prepare and 18 minutes to cook. She uses 35 ounces of fresh local clams for each gallon of the clam chowder, and 22 ounces of clams for each gallon of the seafood chowder.

    Each morning before any employees arrive, 25 pounds of clams and other ingredients are delivered to the restaurant. The restaurant owner sets aside about 4 hours per day to prepare the ingredients for the two chowder soups, and her sous chef can usually spend about 5 hours each day to make the two chowders. Each gallon of the chowder can make about 8 servings, and the profits per serving for the clam chowder and seafood chowder are $2.43 and $1.89, respectively.

    a. Use the provided information and formulate an LP model to maximize the total profit. How many gallons of the clam chowder and seafood chowder should the restaurant make each day? What is the highest profit that can be generated from the two chowders?

    b. Identify binding and nonbinding constraints and slack values, as applicable.

    c. If the restaurant owner wants to make sure that the amount of clam chowder made each day is at least twice as much as the amount of seafood chowder, how many gallons of each chowder should be made?

A.1 IN EXCEL

1. Set up the **parameters table** with two columns: Clam Chowder and Seafood Chowder, and rows for each: Prep Time (min per gallon), Cook Time (min per gallon), Clams required (ounces per gallon)
2. Create a **Per-gallon profit** row and calculate profit for each Clam/Seafood Chowder by multiplying the *profit per serving × 8 servings*.
3. Create a **Decision variables** (gallons to produce) section, and include two columns: *Clam and Seafood*. Enter an initial guess of ***0*** for each.
4. Create an **Objective function** (profit maximization) cell. Use a *SUMPRODUCT* formula that multiplies: *the per-gallon profit row by the row of decision variables (Clam, Seafood)*. This formula returns the total daily profit from the two chowders.
5. Build the **constraints table:**
    - Clams (Ounces)
        - **Left-hand side:** SUMPRODUCT of clams per gallon × decision variables for both clam & seafood chowder
        - **Relation**: ≤
        - **Right-hand side:** total ounces available (convert 25lb * 16 =400 lb 400 ounces)
    - Prep Time (min)
        - **LHS:** SUMPRODUCT of prep time per gallon × decision variables for both clam & seafood chowder
        - **Relation**: ≤
        - **RHS**: total minutes available (convert 4 hours *60 = 240 mins)
    - Cook Time (min)
        - **LHS**: SUMPRODUCT of cook time per gallon × decision variables for both clam & seafood chowder
        - **Relation**: ≤
        - **RHS**: total minutes available (convert 5 hours *60=300 mins)

A.1 IN EXCEL

7. Launch Solver and set the objective:
    a. Go to the Data tab → choose **Solver**.
    b. In Solver, set the Objective to the cell with the **objective function.**
    c. Choose **Max** to maximize total profit.
    d. Set the *By Changing Variable Cells* field to the **row of decision variables.**
    e. **Add each constraint**
    f. **Click Solve using Simplex LP, and keep the solution**

b. Identify binding and nonbinding constraints and slack values, as applicable.

8. **Part (b): Identify binding constraints:**

A constraint is **binding** if the left-hand side equals the right-hand side, Slack = RHS − LHS.

c. If the restaurant owner wants to make sure that the amount of clam chowder made each day is at least twice as much as the amount of seafood chowder, how many gallons of each chowder should be made?

9. Create a copy of the sheet and add a new constraint below the original three:
    - Rule (clam ≥ 2 × seafood) so
        - **LHS = Clam decision variable − 2 × Seafood decision variable**
        - **Relation: ≥**
        - **RHS = 0**
    - Return to Solver and add the new mix constraint.
    - Solve again using Simplex LP.

A.1

a. The restaurant should make 8.3436 gallons of clam chowder and 4.9080 gallons of seafood chowder. The maximum profit is $236.41.

b. The clam and prep time constraints are binding. The cooking time constraint is nonbinding with a slack of 36.4417 minutes.

c. The restaurant should make 8.6957 gallons of clam chowder and 4.3478 gallons of seafood chowder. The maximum profit is $234.78.

QUESTION 2

22. A consumer product company makes two types of dishwasher detergents: regular and concentrate. The company has two manufacturing facilities for making detergent products. The first facility has an operating cost of $120 an hour and can produce 300 ounces of regular detergent products per hour and 220 ounces of concentrate detergent per hour. The second facility has an hourly operating cost of $220 and produces 350 ounces of regular detergent and 450 ounces of concentrate detergent per hour. The company received wholesale orders totaling 4,500 ounces of regular detergent and 5,200 ounces of concentrate detergent.

    a. Formulate and solve the LP model that minimizes costs given the constraints. How many hours should the company operate each facility in order to fulfill the orders and minimize the operating cost?

    b. Identify each binding constraint and report the shadow price and the range of feasibility.

    c. If the hourly operating cost of the second facility is reduced to $200, how many hours should the company operate each facility? What is the minimum operating cost in this scenario?

A.2 IN EXCEL

a. Formulate and solve the LP model that minimizes costs given the constraints. How many hours should the company operate each facility in order to fulfill the orders and minimize the operating cost?

1. Set up the **parameters table** with two *columns*: Facility 1 and Facility 2, and *rows* for each: Operating Cost (per hour), Output of Regular Detergent (ounces per hour), Output of Concentrate Detergent (ounces per hour)
2. Create a **Decision variables (hours to operate)** section, and include two *columns*: Facility 1 and Facility 2. Enter an initial guess of **0** for each.
3. Create an **Objective function** (total operating cost): Use a **SUMPRODUCT** formula that multiplies: *the operating cost per hour row by the row of decision variables*.
4. Build the **constraints table:**
    - Regular Detergent Demand (ounces)
        - **Left-hand side:** SUMPRODUCT of regular detergent output per hour × decision variables for both facilities
        - **Relation**: ≥
        - **Right-hand side:** total ounces required (4,500 ounces)
    - Concentrate Detergent Demand (ounces)
        - **LHS:** SUMPRODUCT of concentrate detergent output per hour × decision variables for both facilities
        - **Relation**: ≥
        - **RHS**: total ounces required (5,200 ounces)
5. Use **Solver** to **minimize** the total operating cost:
    - **Objective:** the Objective function cell
    - **By Changing:** the decision variables
    - Add the **Constraints**
    - Use the **Simplex LP** method, and click **Solve,** and generate the **Sensitivity Report (for part b)**

A.2 IN EXCEL

b. Identify each binding constraint and report the shadow price and the range of feasibility.

6. A constraint is **binding** when the Left-hand side = Right-hand side exactly.
7. **Shadow Price**: For each binding constraint, read the Shadow Price from the Sensitivity Report.

The shadow price shows how much the minimum operating cost would change if the demand increased by one unit, within the allowable range.

8. **Range of Feasibility:** identify the Allowable Increase and Allowable Decrease.

Compute the feasible range:

- Lower bound: RHS − Allowable Decrease
- Upper bound: RHS + Allowable Increase

Within this interval, the shadow price remains valid and the optimal solution structure does not change.

c. If the hourly operating cost of the second facility is reduced to $200, how many hours should the company operate each facility? What is the minimum operating cost in this scenario?

make a copy of your sheet

9. In the **Parameters table**, update the operating cost for Facility 2 from $220/hour to $200/hour.
10. Reset the **decision variables** (hours for both facilities) back to **0** in the Decision Variables section.
11. Run Solver and keep all settings the same as in part (a), click Solve and record the new optimal solution.

A.2

a. The company should operate the first facility for 3.5345 hr and the second facility for 9.8276 hr, incurring the minimum cost of $2,586.2069.

b. Both constraints are binding. For the regular detergent constraint: shadow price is $0.0966 and the range of feasibility is from 4,044.4444 to 7,090.9091 ounces. For the concentrate detergent

constraint: shadow price is $0.4138 and the range of feasibility is from 3,300 to 5,785.7143 ounces.

c. The company should still operate the first facility for 3.5345 hr and the second facility for 9.8276 hr (the same operating schedule as before), but will incur a lower manufacturing cost of $2,389.6552.

Thank you!