Indian Institute of Technology Bombay

IE501 Project Report 2024

Group - 30

Project on Budget Optimization in Clinical Scenario

Author: Kishan Kumar Upadhyay [24N0453]

Author: Manish [24N0451]

Author: Damuka Hemanth Kumar [24N0459]

Author: Yadav Anand Peshkarsingh [24N0460]

Course Instructor: Dr. Avinash Bhardwaj

IE501 Course Project Group - 30

Budget Optimization in Clinical Scenario

❖ Introduction:

Clinical units, such as hospitals, play a vital role in delivering high-quality healthcare services under resource constraints. Key challenges include minimizing operational costs, optimizing budgets, and efficiently scheduling employees and resources to meet community healthcare needs. Effective financial management ensures smooth operations and top-tier care.

Budget optimization balances expenses with patient satisfaction by improving fund allocation across staffing, medical supplies, and equipment maintenance. Strategic planning and optimization models address these challenges while aligning resources with healthcare goals. This project introduces a mathematical model to optimize budgets, reduce costs, enhance resource utilization, and improve patient satisfaction, leading to more efficient healthcare delivery.

❖ Decision Variables:

a_{jt} = { 1; if employee j is given slot t
0; otherwise

b_{qt} = { 1; if patient q is given slot t
0; otherwise

c_{st} = { 1; if resource s is given slot t
0; otherwise

d_j = { 1; if employee j is working overtime
0; otherwise

❖ Parameters:

$\mathbf{U_{jt}}$ = Cost of assigning employee j to slot t

$\mathbf{V_{qt}}$ = Cost of assigning patient q to slot t

$\mathbf{W_{st}}$ = Cost of assigning resource s to slot t

$\mathbf{X_{qt}}$ = Penalty if patient q doesn't receive service during slot t

$\mathbf{Y_j}$ = Overtime cost of employee j

$\mathbf{Z_t}$ = Demand for employee at slot t

$\mathbf{H_j}$ = Maximum working hours of employee j

B = Total budget available

❖ Objective Function:

$$\text{Minimize} \sum_{j=1}^{N}\sum_{t=1}^{T} U_{jt}a_{jt} + \sum_{q=1}^{P}\sum_{t=1}^{T}(V_{qt}+X_{qt})b_{qt} + \sum_{s=1}^{R}\sum_{t=1}^{T} W_{st}c_{st} + \sum_{j=1}^{N} Y_j d_j.$$

❖ Constraints:

- The total number of employees assigned to each time slot must equal the demand for employees at that time.

$$\sum_{j=1}^{N} a_{jt} = Z_t \quad \forall t = 1, \ldots, T$$

- The total number of time slots each employee can be assigned to is limited by their maximum working hours.

$$\sum_{t=1}^{T} a_{jt} \leq H_j \quad \forall j = 1, \ldots, N$$

- Each patient is assigned to exactly one time slot.

$$\sum_{t=1}^{T} b_{qt} = 1 \quad \forall q = 1, \ldots, P$$

- Each resource is allocated to exactly one time slot.

$$\sum_{t=1}^{T} c_{st} = 1 \quad \forall s = 1, \ldots, R$$

- If an employee works overtime, the sum of their assigned time slots must exceed their maximum working hours.

$$d_j \geq \sum_{t=1}^{T} a_{jt} - H_j \quad \forall j = 1, \ldots, N$$

- The total cost of employee assignments and resource allocations must not exceed the budget constraint.

$$\sum_{j=1}^{N} \sum_{t=1}^{T} (U_{jt} a_{jt} + Y_j d_j) + \sum_{s=1}^{R} \sum_{t=1}^{T} W_{st} c_{st} \leq B$$

The decision variables $\mathbf{a_{jt}}$, $\mathbf{b_{qt}}$, $\mathbf{c_{st}}$, $\mathbf{d_{jt}}$ are all binary, i.e., they take values in {0,1}

❖ Code:

The code takes input CSV files for employee assignment costs, patient assignment costs, resource allocation costs, overtime costs, unserved patient penalties, maximum working hours, employee demand, and total budget, then optimizes the total cost to provide an optimal schedule for employees, patients, resources, and overtime workers.

❖ Result:

After solving the optimization problem posed in this context, we have obtained the optimal objective value as 5452 units. Also, we have obtained the schedule for employee, patient and resource allocation.

❖ References:

Homauni, A., Markazi-Moghaddam, N., Mosadeghkhah, A., Noori, M., Abbasiyan, K., & Balaye Jame, S. Z. (2023). Budgeting in Healthcare Systems and Organizations: A Systematic Review. *Iranian Journal of Public Health*, 52(9), 1737-1746.

Yinusa, H., & Faezipour, M. (2020). Optimizing Healthcare Delivery: A Model for Staffing, Patient Assignment, and Resource Allocation. *Healthcare Operations Management Journal, 15*(4), 312-328.