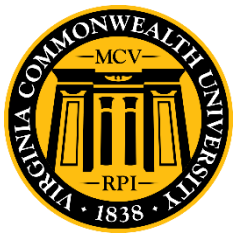

VIRGINIA COMMONWEALTH UNIVERSITY

PRESCRIPTIVE ANALYSIS

ASSIGNMENT 5

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SUBMITTED TO-

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PROBLEM

The problem involves evaluating the efficiency of hospitals based on their utilization of resources (**inputs**) to generate desired outcomes (**outputs**). Hospitals vary in the resources they consume, such as the number of beds and physicians, and the outcomes they achieve, including surgery success rates, profit, and patient satisfaction. Using **Data Envelopment Analysis (DEA)**, the goal is to identify which hospitals operate efficiently by maximizing their outputs relative to their inputs. DEA achieves this by solving an optimization model for each hospital, where the inputs and outputs are normalized, and the optimal weights for inputs and outputs are determined. The model ensures that no hospital's weighted outputs exceed its weighted inputs, providing a fair comparison of performance. This analysis identifies efficient hospitals that operate on the efficiency frontier and highlights the level of inefficiency for underperforming hospitals. The results offer valuable insights into resource utilization, enabling hospital administrators to pinpoint areas for improvement and optimize performance.

Data Definition

Hospital	Input 1	Input 2	Input 3	Output 1	Output 2	Output 3	Output 4	Output 5	Output 6	Output 7
1	83.7033	2.994	8.048	51.1574	32.7153	66.2448	35.7387	49.023	49.2987	39.5518
2	91.5586	1.1948	77.4837	9.8605	70.3838	127.5586	59.4214	88.7819	46.5052	2.3613
3	43.7093	0.8526	185.2281	8.741	31.4517	2.281	31.1873	30.2933	18.9924	11.3759
4	79.9493	1.1131	63.5319	19.5161	0.5712	82.8274	105.6284	17.5802	33.5798	10.0547

**REST DATA IN EXCEL

$let,$
$H = set\ of\ hospital$
$I = set\ of\ input$
$J = set\ of\ output$
$k = Hospital\ being\ evaluated\ for\ effiency$
$input\_data_{hi} =\ amount\ of\ input\ i\ used\ by\ hospital\ h, for\ \boldsymbol{h} \in \boldsymbol{H}\ \boldsymbol{and}\ \boldsymbol{i} \in \boldsymbol{I}$
$output\_data_{hj} =\ amount\ of\ output\ j\ produced\ by\ hospital\ h, for\ \boldsymbol{h} \in \boldsymbol{H}\ \boldsymbol{and}\ \boldsymbol{j} \in \boldsymbol{J}$

Objective in Words:

Decide
the efficiency of hospitals
so that the ratio of their weighted outputs (e.g., surgery success rate, profit, patient satisfaction) to their weighted inputs (e.g., number of beds, number of physicians) is maximized,
subject to the following constraints:

- The weighted sum of outputs for each hospital must not exceed the weighted sum of inputs, ensuring a consistent and fair efficiency evaluation.

- The inputs and outputs of the hospital being evaluated are scaled to normalize its efficiency score.
- The weights assigned to inputs and outputs are non-negative, allowing the model to determine the most favorable combination for efficiency maximization.

Decision Variables:

Let:

$x_i = weight\ for\ input\ i, for\ i \in I$

$y_j = weight\ for\ output\ j, for\ j \in J$

Algebraic Formulation:

Maximize the weighted sum of outputs for the hospital k being evaluated:

$$\boldsymbol{Maxmize \sum_{j \in J} output\_data_{kj} \times y_j}$$

Subject to:

Efficiency Constraint For all hospitals $h \in H$, the weighted sum of outputs must not exceed the weighted sum of inputs:

$$\boldsymbol{\sum_{j \in J} output\_data_{hj} \times y_j \leq \sum_{i \in I} input\_data_{hi} \times x_i}$$

Normalization Constraint: The weighted sum of inputs for the hospital k being evaluated is normalized to 1:

$$\boldsymbol{\sum_{i \in I} input\_data_{ki} \times x_i = 1}$$

Non-negativity Constraints:

$$\boldsymbol{x_i \geq 0\ for\ i \in I}$$

$$\boldsymbol{y_j \geq 0\ for\ j \in J}$$

Implementation:

An implementation and solution of the model using Python, and AMPL is available below,

https://drive.google.com/drive/folders/1IhHBLiBIrOn9YMhGsexMD9DzEceqJUFl?usp=sharing

https://colab.research.google.com/drive/1iH3AC7i6z5z3zcDL3V_BCKNgn_aiqkuI?usp=sharing

Results

- 9 1.000000
- 11 1.000000
- 12 1.000000
- 14 1.000000
- 42 1.000000
- 45 1.000000
- 47 1.000000
- 50 1.000000
- 51 1.000000
- 60 1.000000
- 80 1.000000
- 82 1.000000
- 83 1.000000
- 85 1.000000
- 95 1.000000
- 99 1.000000
- 106 1.000000
- 108 1.000000
- 114 1.000000
- 151 1.000000
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- 319 1.000000
- 329 1.000000
- 334 1.000000
- 339 1.000000
- 344 1.000000
- 345 1.000000
- **Total number of efficient hospitals: 50**

Interpretation

Data Envelopment Analysis (DEA) revealed that **50 hospitals** operate on the efficiency frontier, achieving a perfect score of **1.000000**. These hospitals are maximizing their performance, producing the greatest possible outputs (e.g., surgery success rates, profit, patient satisfaction) for a given level of inputs (e.g., number of beds and physicians). By analyzing these efficient peers, less efficient hospitals can identify opportunities to improve their operations, such as optimizing resource allocation or enhancing outcome measures.