國立臺北大學自然資源與環境管理研究所
109 學年度第二學期『環境系統分析專題』

課程講義(05-06)：績效評估與資料包絡分析

Performance Evaluation and Data Envelopment Analysis

- DATA ENVELOPMENT ANALYSIS
  - □ Performance, Efficiency, Effectiveness, and Productivity => Intensity
    - ➪ CP 值 (Cost-Performance ratio; Price-Performance ratio)、BC Ratio (Benefit/Cost)、資源/能源生產力、Eco-Efficiency
    - ➪ 效率評估方法：平衡計分卡（Balance Score Card, BSC）、比例分析法（Ratio Analysis）、迴歸分析法（Regression Analysis）、財務比率分析法、多準則評估法、生產力及生產效率分析法、資料包絡分析法 (http://www.wunan.com.tw/www2/download/preview/1FQF.PDF)
    - ➪ Effectiveness => Cost Effectiveness => Goal Achievement
    - ➪ Performance (Productivity) = Effectiveness + Efficiency (https://www.springer.com/gp/book/9783030242763)
  - □ Total Factor Productivity (TFP) vs. Production Possibility Set (PPS)
    - ➪ Absolute Efficiency vs. Relative Efficiency
  - □ Key Components of the Data Envelopment Analysis (DEA)
    - ➪ Decision Making Unit (DMU) => Technical vs. Scale Efficiencies; Reference (Peer) DMU
    - ➪ Inputs and Outputs => Formulation Orientations => Returns to Scale
  - □ Formulations of the Charnes, Cooper, and Rhodes (CCR) DEA Model
    - ➪ Constant Return to Scale (CRS)
    - ➪ Envelopment Model vs. Multiplier Models

Table 1.1 CCR DEA model

Input-oriented		
Envelopment model		Multiplier model
$\min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$		$\max z = \sum_{r=1}^{s} \mu_r y_{ro}$
subject to		subject to
$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io}$	$i = 1, 2, \ldots, m;$	$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0$
$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro}$	$r = 1, 2, \ldots, s;$	$\sum_{i=1}^{m} v_i x_{io} = 1$
$\lambda_j \ge 0$	$j = 1, 2, \ldots, n$	$\mu_r, v_i \ge \varepsilon > 0$

(Cooper et al., 2011, Table 1.1, p.13)

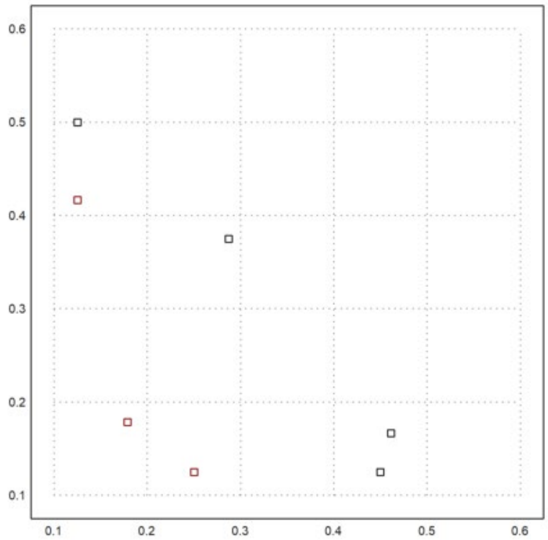
  - □ Variable Return to Scale (VRS) => Banker, Charnes, and Cooper (BBC) Model
  - □ Malmquist Productivity Indexes and DEA

□ A Simple Example (劉春初教授 http://web.cjcu.edu.tw/~lcc/DEA20090228.ppt)

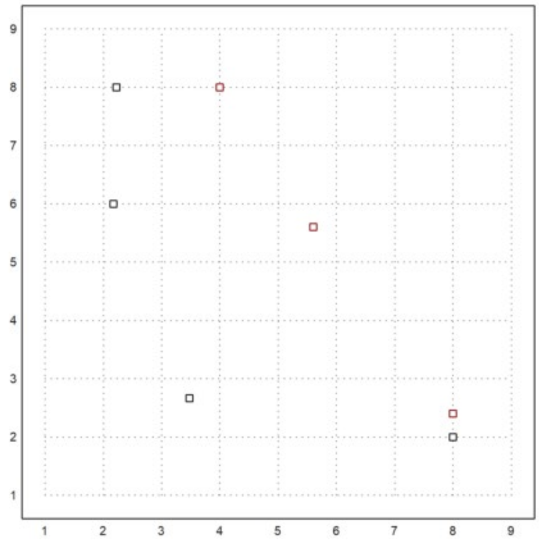
⇨ One output; 2 inputs; and 7 DMU

決策單位	A	B	C	D	E	F	G
投入一	9	8.3	4.6	1.75	1.5	2.5	4
投入二	2.5	3	6	7	5	2.5	2
產出	20	18	16	14	12	14	16

⇨ Production Frontier



$\frac{x_1}{y}$ vs. $\frac{x_2}{y}$



$\frac{y}{x_1}$ vs. $\frac{y}{x_2}$

⇨ Solutions by pyDEA

DMU	Envelopment Model				Multiplier Model			
	I-CRS	I-VRS	O-CRS	O-VRS	I-CRS	I-VRS	O-CRS	O-VRS
A	1	1	1	1	1	1	1	1
B	0.7500	0.7831	0.7500	0.9259	0.7500	0.7831	0.7500	0.9259
C	0.5882	0.8696	0.5882	0.9709	0.5882	0.8696	0.5882	0.9709
D	1	1	1	1	1	1	1	1
E	1	1	1	1	1	1	1	1
F	1	1	1	1	1	1	1	1
G	1	1	1	1	1	1	1	1

□ Undesired Factors => Non-Discretionary and Weak Disposability

□ Ehrlich and Holdren (1971) Impact Equation (I=PAT) and Kaya Identity

⇨ Human impact on the environment (I): Population (P), Affluence (A) and Technology (T)

⇨ Affluence (A): Per capita GDP; Technology (T): Emissions/GDP=> intensity

⇨ Simplified Kaya Identity: CO_2 = GDP×(Energy/GDP)×(CO_2/Energy)

- HOMEWORK #3 (2021/04/27 Due)：*Solve* the second example (7 DMUs with 2 inputs) presented by **Liu** using R, pyDEA and Euler Math Toolbox.