Data Envelopment Analysis of First-Year Courses at Appalachian State University

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Abstract
Data Envelopment Analysis (DEA) is a powerful technique that provides relative comparisons of very different types of depts in an organization. We adapt DEA to analyze distinct activities across projects in industry and government.

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The Project
Analyze required, first-year, general education classes at Appalachian. We assess four large-enrollment course blocks:

I. UCO 1200 First Year Seminar
II. BIO 1101 Bio in Society I, BIO 1102 Bio in Society II
III. ENG 1000 Expos Writing Seminar
IV. MAT 1010 Intro to Math, MAT 1025 Precalculus

DEA allows us to produce a ranking index based on several diverse inputs and outputs.

The Software
We use the ‘Optimization’ and ‘simplex’ packages of Maple, a computer algebra system, to perform the many simplex algorithm runs required by DEA.

(Visit www.maplesoft.com for information about Maple.)

Background: Data Envelopment Analysis

Charnes, Cooper, and Rhodes invented DEA in 1978, basing the technique on “combustion engineering’s ‘efficiency is the ratio of the actual amount of heat liberated . . . to the maximum amount which could be liberated.’”

DEA Strengths
- Multiple input and multiple output models
- Comparison against all combinations of peers
- Inputs and outputs can have very different units

DEA Weaknesses
- Extreme point technique—noisy data causes significant error
- Not absolute efficiency
- Computationally intensive

DEA Linear Program Formulations
For each Decision Making Unit DMU (α = 1...n), with m inputs \(x_{iα} \) and s outputs \(y_{rα} \), define the relative efficiency \(θ^*_α \) by

\[
θ^*_α = \min_θ \sum_{j=1}^n λ_j x_{iα} \leq \sum_{j=1}^n λ_j x_{i0}, \quad i = 1...m
\]

\[
θ^*_α = \max_{θ} \sum_{j=1}^n λ_j y_{rα} = \sum_{j=1}^n λ_j y_{r}, \quad r = 1...s
\]

with all \(λ_j \geq 0\).

Results and Conclusions

Complete Factor Set
- Leads to a convex hull with all data points near the frontier
- No discrimination among DMUs

Subsets of Factors
- UCO at 66.9% efficiency index in relation to size inputs versus success & cost outputs; other DMUs at 100%
- BIO at 72.9% efficiency index in relation to credit hour inputs versus grade & success outputs; other DMUs at 100%

Further Directions
Incorporate more granular assessments by:
- Extending current blocks; e.g. extending first-year mathematics to all ‘Quantitative Literacy’ courses
- Adding each of the four required Perspectives: ‘Aesthetic,’ ‘Historical & Social,’ ‘Local to Global,’ and ‘Science Inquiry’
- Incorporating further, more detailed, cost factors

References