Comprehensive College Ranking System: A DEA-ANP Hybrid Model

Executive Summary

Purpose

This analysis presents a **two-stage hybrid approach** for engineering college selection, combining Data Envelopment Analysis (DEA) and Analytic Network Process (ANP) to help 12th-grade students make informed decisions.

Key Metrics

- **Total Colleges Analyzed:** 30
- **Colleges Shortlisted:** 7
- **Criteria Clusters:** 5
- **Student Rank:** 4,312

Methodology Overview

Stage	Method	Purpose	Output
1	Data Envelopment Analysis (DEA)	Objective efficiency screening	Top 7 efficient colleges
2	Analytic Network Process (ANP)	Subjective preference ranking	Final prioritized list

This hybrid approach balances **objective performance metrics** with **subjective personal priorities**, ensuring both efficiency and student-fit alignment.

Methodology

Stage 1: Data Envelopment Analysis (DEA)

Model Specification

- **Model Type:** Input-Oriented CCR (Charnes-Cooper-Rhodes)
- **Objective:** Evaluate how efficiently colleges convert resources into outcomes
- **Efficiency Score Range:** 0 to 1 (where 1.0 = perfect efficiency)

Input Variables (5 metrics)

The DEA model evaluates the following resource inputs:

1. **Faculty FTE** - Full-time equivalent faculty count
2. **PhD Faculty Count** - Number of doctoral-qualified faculty
3. **Hostel Beds** - Residential capacity
4. **Infrastructure Score** - Quality of facilities and amenities
5. **Operating Expenditure** - Annual operational costs

Output Variables (6 metrics)

The model measures the following outcomes:

1. **Placement Rate** - Percentage of students placed
2. **Average Package** - Mean salary of placed students
3. **Research Publications** - Academic output per year
4. **Student Satisfaction** - Survey-based satisfaction index
5. **Graduation Rate** - Percentage completing degree on time
6. **Inverted Cutoff Rank** - Transformed selectivity metric

Efficiency Calculation

For each college *j*, the efficiency score θ_j is calculated as:

```
θ_j = (weighted sum of outputs) / (weighted sum of inputs)
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where weights are optimized to maximize each college's efficiency score while keeping all scores ≤ 1.

Selection Criteria

- Colleges with **θ = 1.0** are considered perfectly efficient
- Top **7 efficient colleges** were shortlisted for Stage 2 analysis

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Stage 2: Analytic Network Process (ANP)

Overview

ANP evaluates shortlisted colleges based on **5 interdependent criteria clusters** with consideration of internal dependencies and feedback loops.

Criteria Clusters and Weights

Cluster	Weight	Sub-Criteria
Logistics	7.9%	Distance from home, Travel time, Hostel availability
Academic	24.4%	Branch availability, Faculty-student ratio, Curriculum relevance, Rank fit score
Financial	13.7%	Total fee per year, Scholarship availability, Fee flexibility
Campus Life	13.7%	Campus safety, Extracurricular activities, Health facilities
Reputation	40.3%	Alumni network, Industry connections, Accreditations

ANP Process

1. **Pairwise Comparison Matrices:** Experts/students compare criteria importance using Saaty's 1-9 scale
2. **Supermatrix Construction:** Build unweighted, weighted, and limit supermatrices
3. **Principal Eigenvector Method:** Extract priority vectors from each matrix
4. **Interdependency Analysis:** Account for feedback between criteria
5. **Final Priority Calculation:** Compute overall college priorities

Consistency Validation

- **Consistency Ratio (CR)** calculated for all pairwise comparison matrices
- **Acceptable threshold:** CR < 0.10
- Warns users if judgments are inconsistent and require revision

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Results and Findings

DEA Stage Results

Efficiency Distribution

- **10 out of 30 colleges** achieved perfect efficiency ($\theta = 1.0$)
- Mix of large and medium-sized institutions represented
- All shortlisted colleges demonstrate optimal resource utilization

Top 7 Shortlisted Colleges

Rank	College ID	Efficiency Score	Size Category
-	C24	1.0000	Large
-	C14	1.0000	Medium
-	C29	1.0000	Large
-	C28	1.0000	Medium
-	C10	1.0000	Medium
-	C9	1.0000	Large
-	C2	1.0000	Medium

Note: All 7 colleges are equally efficient in DEA; ranking determined in ANP stage.

ANP Stage Rankings

Final Priority Scores

Rank	College	Priority Score	Key Strengths
1	**C29**	**0.1542**	Strong financial position, excellent campus facilities
2	**C24**	**0.1531**	Best logistics (closest to home), good reputation
3	**C14**	**0.1481**	Excellent campus life, strong academics
4	C28	0.1448	Balanced across all criteria
5	C10	0.1421	Best rank fit (cutoff: 35,453)
6	C9	0.1394	Strong reputation and industry ties
7	C2	0.1183	Good academic programs

Student Rank Context

- **Student Rank:** 4,312
- **Best Rank Fit:** C10 (cutoff rank: 35,453)
- **Rank Safety Margin:** 31,141 ranks below cutoff

Future Enhancements

Data Integration

- **Real College Data:** Fetch from NIRF, JoSAA, college websites
- **Live Updates:** Current cutoff ranks, placement rates, fees
- **Historical Trends:** 3-5 year trends for placement and cutoffs

Advanced Analytics

- **Cross-Validation:** Compare with TOPSIS, PROMETHEE, pure AHP
- **Monte Carlo Simulation:** Test robustness under input uncertainty
- **Machine Learning:** Train on past student choices to refine weights
- **Confidence Intervals:** Provide uncertainty bands around scores

User Experience

- **Comparison View:** Side-by-side college comparison with radar charts
- **Export Reports:** Generate PDF reports with detailed breakdowns

Constraint Handling

- **Budget Constraints:** Hard filter for maximum affordable fees
- **Geographic Preferences:** Distance/state/region filters
- **Branch Availability:** Filter by specific engineering disciplines
- **Reservation Category:** Adjust cutoff ranks based on student category

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Conclusions

The system provides reliable, defensible recommendations that balance objective performance metrics with subjective student preferences while maintaining full transparency and customizability.

Appendices

A. Technical Implementation

Programming Language: Python
Key Libraries:

- NumPy (matrix operations)

- SciPy (optimization)
- Pandas (data manipulation)
- PuLP (linear programming for DEA)

B. Sensitivity Analysis Results

Rank stability across 5 scenarios demonstrates that **C29, C24, and C14** consistently appear in the top 3 regardless of weight configuration, indicating robust recommendations.

Report Generated: December 24, 2025