Salo & Punkka (2011): Ranking intervals and dominance relations for ratio-based efficiency analysis

Example of a successful major revision

31.5.2012

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Doctoral programme seminar "Scientific writing", 30.5.-1.6.2012
CCR-DEA (Charnes, Cooper and Rhodes)

- Applies *efficiency ratios* to compare DMUs that use several inputs to produce several outputs

\[
E_k (u, v) = E_k = \frac{\text{value of outputs}}{\text{value of inputs}} = \frac{\sum_{n=1}^{N} u_n y_{nk}}{\sum_{m=1}^{M} v_m x_{mk}}
\]

- *Efficient* DMUs have highest efficiency ratio with some non-negative weights \((u, v)\)

- *Inefficient* DMUs characterized by their *efficiency score*
  
  \[
  \text{Efficiency score} = \max_{u, v} [E_k (u, v)/\max \{E_1 (u, v), \ldots, E_K (u, v)\}]
  \]
  
  - Based only on the weights most favorable to the DMU
  - ”Rank reversals”: order of two DMUs’ efficiency scores can depend on what other DMUs are considered
Our contributions

- Based on comparing efficiency ratios
  1. Given a pair of DMUs, is the first DMU more efficient than the second for all feasible weights? → Dominance relations
  2. What are possible efficiency rankings of a DMU over all feasible weights? → Ranking intervals
  3. Considering all feasible weights, how efficient is a DMU compared to the most (or the least) efficient DMU of a benchmark group? → Efficiency bounds

- Can be computed in presence of preference statements about the relative values of outputs and inputs
  - Feasible weights = non-negative, fulfill possible preference statements
Editor’s letter

DECISION: **Major Revision**

FROM: Prof. X, Department Editor, Management Science

Dear Professor Salo:

Your paper has been reviewed by **two referees and an AE**. One referee is quite positive and another referee saw major problems with your paper but was willing to look at a substantially revised paper (this latter reviewer recommended Major Revision). The AE raised questions in an email to me about the fit of the paper with Management Science and felt that the paper may have a higher impact in pure Operations Research type journals. He was however very open and willingness to be persuaded otherwise.

I read the paper and find myself agreeing with the AE’s assessment. Hence, I would like to invite you to persuade us in a major revision the following 2 major concerns (besides those of the reviewers):

1. **Convince the review team that your approach is superior to Cross Efficiencies approach** at least in some application domains.

2. **Demonstrate that your approach works in multiple settings** (at least 2). This will increase the paper’s relevance for readers in Management Science. In this regard, I really like the AE’s idea of a meta-application and believe that it will significantly strengthen the paper.

I look forward to reading the revised paper.
Cross Efficiencies approach

- Editor: **Convince the review team that your approach is superior to Cross Efficiencies approach** at least in some application domains.
- In the first submitted version of the paper, cross efficiencies were not discussed, at all.
- DMU’s cross efficiency = an index based several weights, but not all weights
  - Not as extensive as our approach
  - Weights used in computing a DMU’s cross efficiency depend on what other DMUs are included in the analysis
    - Smells like a possibility of rank reversals
Solution: new subsection *Comparisons with cross efficiency analysis*

- New results

  1. If DMUs are ranked based on their cross efficiencies (CE), introduction of new DMUs can change 2 DMUs’ mutual ranking
     - Rank reversals

  2. A DMU does not necessarily achieve its CE ranking with any feasible weights
     - We first tried to prove that the opposite holds.

  3. A dominated DMU can have as high a cross efficiency as the DMU that dominates it
Response to the referees

• “We have added a new Section 3.6. which examines relations between cross-efficiency analysis and our efficiency results. Specifically, we have identified several concerns with cross-efficiency analysis:
  – Whenever any two DMUs, say DMU\textsubscript{k} and DMU\textsubscript{l},…”
"Demonstrate that your approach works in multiple settings"

- Editor: "I really like the AE’s idea of a meta-application"
  - Well, we don’t: concept "meta-application" was new to us
    - Google wasn’t too useful either

- The case study – Evaluation of TKK’s departments – received a lot of attention in the manuscript
  - This case study started the research behind the paper

- DEA has been used widely to compare universities or organizations within universities; these received too much attention in the manuscript’s literature review
Solution

1. Shorten the *higher education* part in literature review of DEA applications

2. Take two application examples from literature and show that dominance relations, and ranking intervals
   1. Are in line with the results of the original applications
   2. Provide additional insights: ”Robots 4 and 20 are the least efficient of all for some weights, although they are CCR-DEA-efficient”

3. Add the new application domains *technology management* and *health care* to the literature review
   • New examples gave also an opportunity to emphasize differences between cross efficiencies and our results
Response to the referees

• “Section 2 has been shortened significantly. Some references to the literature are given for the three application areas (higher education, health care, technology management) for which numerical results are presented in Section 4.”
Referees’ concern not mentioned by the editor: feasible weights

1. “Greater discussion of what constitutes “feasible weights” is in order”
2. “A case needs to be made for why it is critical for a decision-maker to consider multiple sets of weights with preferences. In most decision making scenarios, managers have information on what the critical inputs and outputs are and based on that weight restrictions are specified. While your approach provides a range of efficiency scores for a DMU, it is possible that some of these scores are based on weight restrictions that may not make functional sense for a manager. This issue needs to be justified.”
3. “It can be quite difficult for the decision-maker to specify multiple sets of preferences based on inputs and outputs. How can one resolve this problem in an actual decision making setting.”
   - These comments were quite surprising to us
   - Misunderstanding resulting from our too concise presentation; We added clarifying simple examples and references
Response to the referees about the critique concerning ‘feasible weights’

1. “The second paragraph in Section 2 has been expanded to explain that weights represent the DM’s preferences concerning the value of different amounts for inputs and outputs. More links to assurance regions and their specification are also given.”

2. “We have clarified how the DM’s (several) preference statements (i.e. weight restrictions) define one feasible set of feasible weights for outputs and one for inputs. Also the close link between the feasible sets and the specification of assurance regions is noted in Section 2. Our results can be computed whenever assurance regions can be elicited using appropriate techniques; but they can also be applied when there are no weight constraints.”

3. “We have clarified that only one set of weights for the outputs and one for the inputs are applied and that existing preference elicitation techniques can be applied. Elicitation of preferences is not necessary - the first example on the screening of robots in Section 4 illustrates that the results can be applied in the absence of any preference information. More generally, the DM is not forced to specify multiple sets of preferences.”
Conclusion

• Our revision process took a year 6/2009 – 6/2010
• Our focus on the major concerns raised by the editor
  – All other referees’ questions, concerns, suggestions, and comments were responded to, too
  – Some referees’ suggestions did not lead to changes
• Accepted after the second submission 9/2010
  – ”The authors have addressed my concerns and I found the revised manuscript to be much better than the original. Reorganizing the paper, offering more examples, and contrasting the proposed method with cross-efficiency (as suggested by the other reviewer) all have contributed to the improvement.”