Evaluation of research in efficiency and productivity: A survey and analysis of the first 30 years of scholarly literature in DEA

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The authors wish to dedicate this compendium of DEA’s historical accomplishments to one of its founders, Professor William W. Cooper

Abstract

Since the original Data Envelopment Analysis (DEA) study by Charnes et al. [Measuring the efficiency of decision-making units. European Journal of Operational Research 1978;2(6):429–44], there has been rapid and continuous growth in the field. As a result, a considerable amount of published research has appeared, with a significant portion focused on DEA applications of efficiency and productivity in both public and private sector activities. While several bibliographic collections have been reported, a comprehensive listing and analysis of DEA research covering its first 30 years of history is not available.

This paper thus presents an extensive, if not nearly complete, listing of DEA research covering theoretical developments as well as “real-world” applications from inception to the year 2007.

A listing of the most utilized/relevant journals, a keyword analysis, and selected statistics are presented.

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1. Introduction

The present bibliography includes most of the references published in the field of Data Envelopment Analysis (DEA) up to the year 2007. Some publications in 2007 are also listed, but not included in the statistics. To the best of the authors’ knowledge, this listing appears to be the most complete source of references on DEA and its applications in measuring the efficiency and productivity of decision making units (DMUs). The authors hope that this new updated bibliography will assist researchers and other scholars as they develop new frontiers in DEA.
The authors wish to thank all those colleagues who continue to submit copies of their papers at [http://www.deazone.com/bibliography](http://www.deazone.com/bibliography) [2], and would appreciate receiving additional DEA-related articles for incorporation into future versions of the bibliography. Due to sheer size and volume, however, it is not possible to guarantee a complete absence of inaccuracies or omission of data. Should you find any error(s), please feel free to report them to the authors at biblio@DEAzone.com.

2. DEA bibliography

In 1995, the website [www.DEAzone](http://www.DEAzone) was created with the hope of including the full set of DEA resources under a single “umbrella,” to be accessed by interested researchers and practitioners. Since then, our DEA bibliography has been regularly updated with the kind support of its many users.

Several other bibliographies have also been reported in the literature, including those of Tavares [3], Emrouznejad and Thanassoulis [4–6], Seiford [7–8] and Gattoufi et al. [9–10]. In compiling the current bibliography, the authors expanded boundaries by searching a variety of both traditional and newer databases including Science Direct ([www.sciencedirect.com](http://www.sciencedirect.com)), EBSCO ([www.ebsco.com](http://www.ebsco.com)), Google Scholar ([http://scholar.google.com](http://scholar.google.com)), JSTOR ([http://uk.jstor.org/](http://uk.jstor.org/)) and Pro-Quest ([http://proquest.umi.com](http://proquest.umi.com)).

The evolution of DEA as a worldwide accepted OR/MS tool has been tracked here in terms of the increases of both publications and authors. It is apparent from our analysis of DEA’s keywords/subject matter, that the method is emerging as a significant and essential tool in a large number of diverse management science fields.

Our extensive literature searches have identified more than 4000 research articles published in journals or book chapters. Books and papers published in/as conference proceedings were also included; but, articles presented at various events and working/research papers published as internal documents, were not considered. To provide some sense of the field’s ongoing expansion, had we included unpublished dissertations, working/research manuscripts, and papers presented at conferences/events, the bibliography count would have exceeded 7000 entries!

A classification of qualified articles by year reveals that a large percentage of the research pool has been published in the last five years, with 2004 being the peak year for articles published in refereed journals.

Banking, education (including higher education), health care, and hospital efficiency were found to be the most popular application areas. An overview of the DEA bibliography database through selected summary statistics indicates that 89% of publications are in the form of journal articles, with 9.4% appearing as book chapters or proceedings, and 1.6% as books themselves.

In total, 2500 distinct authors have been identified, with the average number of authors per publication being nearly two. Based on approx. 75% of the data base, about 2000 distinct keywords were found, with an average of 3.5 per publication.

The next section provides a series of selected statistics involving the papers, keywords, journals, and authors within our DEA database.

3. DEA publication statistics

3.1. Statistics involving publications by year

Fig. 1 shows the distribution of DEA-related articles published by year. Note that between the seminal work of Charnes, Cooper and Rhodes (CCR) in 1978 [1] and the year 1995, there was literally “exponential” growth in the number of publications. Between 1995 and 2003, the number of relevant publications stabilized at about 226 per year. However, in last 3 years (2004–2006), the number again increased to approximately 360 per year. These numbers suggest that, in the spirit of a product life cycle, a maturity phase for DEA began in or around 1995.

3.2. Statistics involving publications by journal

Table 1 lists the 20 journals that have published the greatest number of DEA papers in the past 30 years. Journals such as *European Journal of Operational Research, Journal of Productivity Analysis*, and *Journal of*
the Operational Research Society are the most utilized. The reason is clearly that DEA theory and many DEA applications fall within the fields of operations research and management science, exactly the arenas covered by these journals.

3.3. Statistics involving publications by authors

In total, 2500 distinct DEA authors were identified, with an average of two per publication. Approximately 30% of all publications were written by a sole/single author, while nearly 40% were prepared by two authors. Fig. 2 shows the distribution of publications by number of authors.

Table 1

<table>
<thead>
<tr>
<th>Journal</th>
<th>No. of papers</th>
<th>% of papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>EJOR: European Journal of Operational Research</td>
<td>373</td>
<td>23.0</td>
</tr>
<tr>
<td>JPA: Journal of Productivity Analysis</td>
<td>242</td>
<td>14.9</td>
</tr>
<tr>
<td>JORS: Journal of the Operational Research Society</td>
<td>164</td>
<td>10.1</td>
</tr>
<tr>
<td>Applied Economics</td>
<td>86</td>
<td>5.3</td>
</tr>
<tr>
<td>Annals of Operations Research</td>
<td>83</td>
<td>5.1</td>
</tr>
<tr>
<td>Management Science</td>
<td>83</td>
<td>5.1</td>
</tr>
<tr>
<td>OMEGA</td>
<td>73</td>
<td>4.5</td>
</tr>
<tr>
<td>Applied Mathematics and Computation</td>
<td>63</td>
<td>3.9</td>
</tr>
<tr>
<td>Socio-Economic Planning Sciences</td>
<td>63</td>
<td>3.9</td>
</tr>
<tr>
<td>International Journal of Production Economics</td>
<td>58</td>
<td>3.6</td>
</tr>
<tr>
<td>Computer and Operations Research</td>
<td>48</td>
<td>3.0</td>
</tr>
<tr>
<td>International Journal of Systems Science</td>
<td>41</td>
<td>2.5</td>
</tr>
<tr>
<td>Journal of Econometrics</td>
<td>37</td>
<td>2.3</td>
</tr>
<tr>
<td>Applied Economics Letters</td>
<td>35</td>
<td>2.2</td>
</tr>
<tr>
<td>Journal of Banking and Finance</td>
<td>35</td>
<td>2.2</td>
</tr>
<tr>
<td>Health Care Management Science</td>
<td>29</td>
<td>1.8</td>
</tr>
<tr>
<td>Journal of Medical Systems</td>
<td>29</td>
<td>1.8</td>
</tr>
<tr>
<td>Journal of Operations Research Society of Japan</td>
<td>28</td>
<td>1.7</td>
</tr>
<tr>
<td>System Engineering Theory and Practice</td>
<td>26</td>
<td>1.6</td>
</tr>
<tr>
<td>Review of Economics and Statistics</td>
<td>25</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>1621</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Fig. 1. Distribution of DEA publications by year.
Interestingly, 22% of all papers were written by the “top” 12 authors. William W. Cooper, one of the founders of DEA, is the author with most references in the DEA database. He had a total of 122 publications, which represents nearly 14% of relevant papers written by these 12 authors. Fig. 3 shows the distribution of contributions made by each of the authors. They have all likely published other papers, but they were not included in the current study as the data base is (obviously) restricted to DEA-related research.

3.4. Statistics involving number of pages (size) of publications

In excess of 55,000 pages of scholarly publications have been written on DEA-related material over the last 30 years, with an average of 12.5 pages per article. Nearly 20% of the manuscripts are between nine and 11 pages in length, with approximately 70% being between seven and 17 pages. Fig. 4 shows the distribution of articles by number of pages. Overall, DEA papers appear to have a distribution by length/pages similar to those found in most other OR/MS fields of study.

3.5. Statistics involving keywords used

Keywords for about 75% of the DEA papers were either given or could otherwise be ascertained. Approximately 2000 distinct keywords were reported, with an average of 3.5 keywords per publication. Table 2 lists the most popular keywords by number of publications.
4. Future trends

There is little doubt that DEA and its applications will continue to be a primary arena of research going forward. We see at least three reasons for this trend continuing in strong fashion:

I. Measuring efficiency and productivity of large organisations is a non-trivial exercise, involving a complex multi-input/output structure. DEA technology, by design, naturally accounts for such issues efficiently and effectively.

II. There is an inexhaustible number of real-world applications involving efficiency measurement available to stimulate academics’ and practitioners’ interests in conducting research. Evidence of this phenomenon is clearly shown in the current bibliography. As DEA technology matures further, “late majority” and “laggard” investigators will likely enter the field, further adding to the data base.

### Table 2

<table>
<thead>
<tr>
<th>Keywords</th>
<th>No. of publications</th>
<th>Keywords</th>
<th>No. of publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEA or Data Envelopment Analysis</td>
<td>1637</td>
<td>Mathematical programming</td>
<td>118</td>
</tr>
<tr>
<td>Efficiency</td>
<td>558</td>
<td>Optimization</td>
<td>112</td>
</tr>
<tr>
<td>Decision making unit(s)</td>
<td>392</td>
<td>Health care or hospital</td>
<td>103</td>
</tr>
<tr>
<td>Linear programming</td>
<td>341</td>
<td>Multivariate analysis</td>
<td>89</td>
</tr>
<tr>
<td>Decision theory</td>
<td>269</td>
<td>Production</td>
<td>84</td>
</tr>
<tr>
<td>Mathematical models</td>
<td>216</td>
<td>Parametric</td>
<td>80</td>
</tr>
<tr>
<td>Productivity</td>
<td>215</td>
<td>Benchmarking</td>
<td>78</td>
</tr>
<tr>
<td>Operations research</td>
<td>215</td>
<td>Regression analysis</td>
<td>76</td>
</tr>
<tr>
<td>Economics</td>
<td>192</td>
<td>Production control</td>
<td>73</td>
</tr>
<tr>
<td>Management</td>
<td>181</td>
<td>Statistical models or methods</td>
<td>72</td>
</tr>
<tr>
<td>Performance (management, or evaluation)</td>
<td>176</td>
<td>Humans resource allocation</td>
<td>61</td>
</tr>
<tr>
<td>Bank or banking</td>
<td>135</td>
<td>Statistical analysis</td>
<td>58</td>
</tr>
<tr>
<td>Nonparametric</td>
<td>120</td>
<td>Education</td>
<td>44</td>
</tr>
<tr>
<td>Technical efficiency</td>
<td>120</td>
<td>Nonparametric statistics</td>
<td>40</td>
</tr>
</tbody>
</table>

Fig. 4. Distribution of DEA publications by number of pages.
III. The ability to obtain raw study data is relatively easier now than it was a decade ago. This bibliography thus shows that most published DEA applications arose in the US, UK, and other developed nations. A derivative of this phenomenon will likely be studies looking into the comparative analysis of efficiency.

While there has been an increasing number of DEA studies originating in less developed countries, the authors speculate that, unfortunately, such growth may not persist. This is due to the fact that many countries’ information technologies are not as advanced as those of the developed countries, and their adoption of DEA (and other) technology can lag by a matter of years.

5. Limitations of the current study

Readers should use some level of caution in interpreting results of this survey as the findings are based on data collected only from journal papers, and articles published in books and proceedings. The results thus do not include all real-world DEA publications. In this regard, we have reviewed only academic/professional journal articles. Working/research papers, conference presentations (not published) and doctoral dissertations are excluded, as we assume that high-quality research would eventually be published in the very journals covered here.

Also, many foreign and/or newer journals might not have been included if they are not English language publications.

Finally, due to the often lengthy journal review process, some research reported in our survey may lag behind the actual adoption of recommendations.

While the bibliography was, to be sure, compiled from a wide variety of sources, in the end it represents the efforts of its authors and, consequently, no claim can be made as to its completeness. Any corrections, additions, and/or suggestions will be welcomed in order that the bibliography may be revised and redistributed in an ongoing complete and corrected form.

6. Conclusions

The current literature survey of DEA’s 30 year history, and its comparisons with previous reviews, have revealed some important insights into the trends underlying DEA research. It is hoped that these findings will assist both researchers and practitioners in better understanding the current status of this state-of-the-art technology, and in continuing to move the field forward in the future.

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Appendix A. Supplementary data


References

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