PJSRR (2015) 1(1): 27-32

Pertanika Journal of Scholarly Research Reviews
http://www.pjsrr.upm.edu.my/

Data Envelopment Analysis Models and Software Packages for Academic Purposes

Abdullahi ILIYASU, *[a] Zainal Abidin MOHAMED,[a] & Rika TERANO
[a]Department of Agribusiness and Information System, Faculty of Agriculture, Universiti Putra Malaysia, Selangor Malaysia.
*manawaci@yahoo.co.uk

Abstract – Data envelopment analysis (DEA) is a popular technique used in measuring the performance of an industry. DEA has wide applications in agriculture, manufacturing, health care, transportation, education, energy and environment, as well as banking and finance. However, many students and academicians are in dilemma in finding the appropriate software to execute a particular DEA model. In recent years, different DEA software packages have been developed by some universities and companies for both academic and commercial purposes. The software packages offered wide varieties of most recent DEA models that could be used in science and technology. Some of these software packages are free for academic users while others are commercialised. In this study, nine different DEA software packages were reviewed. Among them, only three are free for academic purposes while four have been commercialized. One of the former is still in the development stage, but expected to be available soon.

Keywords: Academic, commercial, data envelopment analysis, review models, software packages

Introduction

Data envelopment analysis (DEA) involves the application of linear programming technique to estimate the performance of an industry such as agriculture, health care, transportation, education, manufacturing, power, energy and environment, communication, banking, and finance (Liu et al., 2013). Table 1 shows the number of articles published in various industries that employed DEA models in their data analysis. In addition, many empirical research studies that employed DEA models as tools of analysis have been published in ISI or Scopus journals (see Table 2).

Since the novel works by Charnes et al. (1978), many software packages have been developed to applied DEA models in various industries. Barr (2004), Hollingsworth (2002), and Herrero and Pascoe (1997) did a good review of these software packages. However, some of these software packages are no longer available for empirical analyses while new ones have emerged. Furthermore, many models that are previously undiscovered are now available. The recent DEA models include dynamic DEA with network such as a slack-based measure approach (Tone & Tsutsui, 2014), an alternative approach of a slack-based measure of super-efficiency in DEA, (Fang et al., 2013), a modified super-efficiency measure based on simultaneous input–output projection in data envelopment analysis (Chen et al., 2011), super-efficiency in DEA by effectiveness of each unit in society (Nuara et al., 2011), a slack-based measure of super-efficiency in DEA (Du et al., 2010), an epsilon-based measure of efficiency in DEA (Tone & Tsutsui, 2010), and variations on the theme of slacks-based measure of efficiency in DEA (Tone, 2010). Other models include network DEA such as a slacks-based measure approach (Tone & Tsutsui 2009), models for performance benchmarking (Cook et al., 2004), Undesirable Measure (Seiford & Zhu, 2002), a slack-based measure of super-efficiency in DEA (Tone, 2002), a slack-based measure of efficiency in DEA (Tone, 2001), Network DEA (Färe & Grosskopf, 2000), and bootstrapping DEA (Simar & Wilson 1998).

Consequently, a need arises to review existing packages to help students and academicians to select the one that best fits the DEA model of interest. Information on the DEA software packages such as license price, developers, models, and website are, therefore, of paramount importance. It is against this backdrop that this review study is conducted.

Table 1: DEA applications in industries

Industries	Total no. of papers	(%)	2005–2009
Banking	323	17.8	147
Health care	271	14.9	107
Agriculture	258	14.2	140
Transportation	249	13.7	131
Education	184	10.1	75
Power	156	8.6	87
Manufacturing	146	8	75
Energy	109	6	75
Communication	70	3.9	28
Finance	51	2.8	33

Source: Liu et al. (2013)

Commercial DEA software packages

In this study, five commercialized DEA software packages are discussed in details. Three out of these five packages (DEA Solver, Frontier analyst, and MaxDEA) were developed by commercial companies. The other two (PIM-DEA and DEAFrontier) were developed by universities/polytechnics (see Table 3).

Table 2: Commercial and academic DEA software

Software	Developer	License price (single CPU)	
		Academic	Commercial
DEA-Solver	SAITECH, Inc, USA	$800	$1,600
Frontier Analyst	Bonxia Software Ltd, Uk	£395-£3995	£395-£3995
PIM-DEA	Emrouznejad A. and Thanassoulis E.	£245-£966	£490-£1932
DEAFrontier	Joe Zhu	$699	$2,889
MaxDEA	Beijing Res. & Con. Com. Ltd China	$890	&2000
FEAR	Paul W. Wilson	Free	$180
DEAP	Tim Coelli	Free	Free
EMS	Holger Scheel	Free	Free

DEA Solver Pro version

The DEA Solver Pro version is developed by SAITECH Inc., New Jersey, USA and runs within Microsoft Excel. The latest release is Version 10.0, which has additional features not available in the previous versions. The lists of comprehensive models in this package are shown in Appendix A. The license price for single central processing unit (CPU) is $800 (academic purposes) and $1600 (commercial purposes) as illustrated in Table 3. However, a temporary license is also available at a price of $200, $250 and $350 for classes comprising up to 20, 30, and 40 students, respectively. The software package can be purchased from the developer's website (*http://www.saitech-inc.com*). Alternatively, a potential user may buy a textbook (Cooper et al., 2006) to use the student trial version packaged with the book. The student trial version is, however, limited to only 50 Decision Making Units (DMUs).

Frontier Analyst
Frontier Analyst is developed by Bonxia Software Limited, UK. The strongest feature of this software is its ability to display a variety of results. These include graphs of technical efficiency scores, distribution of efficiency tables, frontier plots, pie charts, reference set frequency, X-Y plots, and efficiency plots. Appendix A displays different DEA models available in this software package.

However, unlike most of the DEA software packages reviewed, there is no difference between the license prices for academic or commercial users for Frontier Analyst. The license price escalates as the number of DMUs increases from £395 (75 DMUs only) to about £3995 (20000 plus). Furthermore, the cost for a single CPU and a three-month trial version with a maximum of 500 DMUs is £295. The annual maintenance and upgrading of the software costs about £289 per CPU but it is optional. Therefore, Frontier Analysis is the most expensive among all the commercial DEA software packages based on this review. This software package can be bought online through the developer's website (*www.bonxia.com*).

Performance Improvement Management Software (PIM-DEA)
PIM-DEA Version 3 is developed by A. Emrouznejad and E. Thanassoulis at Aston Business School, Aston University Birmingham, England. This software can handle large data sets, which can be directly imported from Microsoft Excel. Similarly, outputs can be easily exported to Microsoft Excel including different types of graphs for presenting results. Additionally, it allows computation of different DEA models as showed in Appendix A.

PIM-DEA, same as Frontier Analyst, has a variety of prices depending on the license type (academic or commercial), validity type (permanent or temporally), number of DMUs, additional packages, maintenance duration and postal methods. For instance, the permanent license price for academic purposes is £245 (100 DMUs) to £966 (5000 DMUs) whereas £490 (100 DMUs) to £1932 (5000 DMUs) for commercial users. PIM-DEA is the second most expensive DEA software package based on this review. For further information on PIM-DEA, visit the developer's website (*www.deasoftware.co.uk*).

DEA Frontier
DEA Frontier is written by Joe Zhu of Operations and Industrial Engineering, School of Business, Worcester Polytechnic Institute, USA. The software solves different DEA models (Appendix A) using Microsoft Excel solver and with no limitation in the number of DMUs, inputs or outputs. However, unlike most DEA software, well-illustrated tutorials are available online on how to use the software to solve various DEA models. Although the software is commercialized, it has a free download trial version, but the trial version can only handle 20 DMUs and has very limited DEA models. The developer advised potential users to try the trial version before purchasing the licensed version. The license prices for single CPUs are $699 and $2889 for academic and commercial purposes, respectively. This license includes one month free technical support for using the software package only. The pricing and order information is available on the developer's website (*www.deafronier.net*).

MaxDEA
MaxDEA is developed by Beijing Real World Research and Consultation Company Limited. This software is easy to use because it comes in a folder and as such requires no installation. Multiple DEA models can be run at the same time and results can be displayed in Microsoft Excel. The software is of two types, basic and professional. The former allows free download, but it also has a limited number of DEA models that can be executed. On the other hand, the latter is strictly commercialized but deals with comprehensive DEA models as shown in Appendix A. The license price varies depending on the validity type (permanent or temporal) and usage purpose (commercial or academic). The one year license price per single CPU is $360 and $800 for academic and commercial purposes, respectively. On the other hand, the perpetual license price for a single user is $890 and $2000 for academic and commercial users. However, the prices of the license escalate as the number of DMUs increases. Further information on the software can be obtained from the developer's website (*www.maxdea.cn*).

Free DEA software packages (academic purposes only)

Unlike commercial DEA software, the free downloadable packages are developed by universities. Although Frontier Efficiency Analysis in R (FEAR) is free for academic purposes, a license fee needs to be paid for commercial usages.

Frontier Efficiency Analysis in R (FEAR)

FEAR is developed by Paul W. Wilson of Department of Economics and School of Computing, Clemson University, USA. Unlike most DEA software, FEAR works in General Purpose Statistical Package called R, which can be freely downloaded from the website. However, in order to use FEAR, R needs to be downloaded first in the CPU. The FEAR library is then linked to R for various DEA computations. The FEAR package is free for academic purposes, but users must cite Wilson (2008) in all reports, papers, and publications. On the other hand, the FEAR package is not free for commercial users, but costs only $180 (single CPU license). The user guide and FEAR packages are available at the following website: *www.clemson.edu/economics/faculty/Wilson/software/FEAR.*

Data Envelopment Analysis Program (DEAP)

DEAP is a DOS programme developed by Tim Coelli of Centre for Efficiency and Productivity Analysis (CEPA), School of Economics, University of Queensland, Australia. This software can be downloaded freely from the website (*www.uq.au/economics/cepa/deap.php*) in zip form, which contains user guide (Coelli, 1996), read me, and many short examples. Three text files are normally used when conducting an analysis using DEAP. These include data file, instruction file and output file, and all can be edited according to the user analysis. Three analysis options are available in DEAP, standard CRS and VRS DEA models, cost and allocative efficiencies, and Malmquist DEA approach (Appendix A). DEAP is the most popular DEA software package especially among students and academicians perhaps because it is user friendly.

Efficiency Measurement System (EMS)

EMS Version 1.3 is developed by Holger Scheel at University of Dortmund, Germany. The software is free for download for academic purposes. EMS accepts data files from Microsoft Excel or text format, and it operates in Window 9x/NT. There is no limitation in the number of inputs, outputs, and DMUs in using the software. The EMS is distributed in zip file together with the user guide from the website (*www.holger-scheel.de/ems/*).

Data Envelopment Analysis using Stata (DEAS)

DEAS is not yet available for academic and commercial purposes because it is still in the developing stage. According to the developers, the package was registered with Source Forge.net on January 3, 2013. However, the main aim of developing DEAS is to replace the existing DEASTATA that was proposed for management performance analysis. According to the developers, DEAS models will include CCR, BCC, slack-based measure of efficiency, super-efficiency, allocative efficiency, revenue efficiency, profit efficiency, cost efficiency, free disposal efficiency, additive model, virtual price model, and Malmquist productivity index among others.

Conclusion

The study reviewed nine different DEA software packages for executing various analysis models. Three of these software packages are free for academic purposes while the remaining five need to be purchased accordingly. The other one is still in the developing stage, and expected to be available soon. The major shortcoming of all these software packages reviewed is that none of them performs all the DEA analysis. In addition, the free software packages have limited number of DEA models when compared with the commercial versions. The licensed software is very expensive and hence not affordable by many students and academicians especially in developing countries. Effort should be geared towards producing a single software that computes all the DEA models and at a cheaper price or free of charge to enable wider applications.

References

Barr, R. S. (2004). DEA software tools and technology. *Handbook on Data Envelopment Analysis,* Boston: Kluwer Academic Publishers.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429-444.

Chen, J.-X., Deng, M., & Gingras, S. (2011). A modified super-efficiency measure based on simultaneous input–output projection in data envelopment analysis. *Computers & Operations Research, 38*(2), 496-504.

Coelli, T. J. (1996). A guide to FRONTIER version 4.1: A computer program for stochastic frontier production and cost function estimation: CEPA Working papers.

Cook, W. D., Seiford, L. M., & Zhu, J. (2004). Models for performance benchmarking: measuring the effect of e-business activities on banking performance. *Omega, 32*(4), 313-322.

Cooper, W. W., Lawrence M. S., & Kaoru Tone (2006). Data Envelopment Analysis: A comprehensive text with models, applications, references and DEA-Solver Software. Second Edition. New York: Springer.

Du, J., Liang, L., & Zhu, J. (2010). A slacks-based measure of super-efficiency in data envelopment analysis: a comment. *European Journal of Operational Research, 204*(3), 694-697.

Fang, H.-H., Lee, H.-S., Hwang, S.-N., & Chung, C.-C. (2012). A slacks-based measure of super-efficiency in data envelopment analysis: An alternative approach. *Omega - The International Journal of Management Science, 41*(4): 731–734.Färe, R., & Grosskopf, S. (2000). Network dea. *Socio-economic planning sciences, 34*(1), 35-49.

Herrero, I., & Pascoe, S. (2002). Estimation of technical efficiency: a review of some of the stochastic frontier and DEA software. *Computers in Higher Education Economics Review, 15*(1), 38-43.

Hollingsworth, B. (1997). A review of data envelopment analysis software. *Economic Journal, 107*(443): 1268-1270.

Liu, J. S., Lu, L. Y., Lu, W.-M., & Lin, B. J. (2013). A survey of DEA applications. *Omega, 41*(5), 893-902.

Kaoru Tone, M. T. (2014). Dynamic DEA with network structure: A slacks-based measure approach. *Omega, 42*(1), 124-131.

Noura, A., Hosseinzadeh Lotfi, F., Jahanshahloo, G. R., & Fanati Rashidi, S. (2011). Super-efficiency in DEA by effectiveness of each unit in society. *Applied Mathematics Letters, 24*(5), 623-626.

Seiford, L. M., & Zhu, J. (2002). Modeling undesirable factors in efficiency evaluation. *European Journal of Operational Research, 142*(1), 16-20.

Simar, L., & Wilson, P. W. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models. *Management science, 44*(1), 49-61.

Tone, K. (2001). A slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research, 130*(3), 498-509.

Tone, K. (2002). A slacks-based measure of super-efficiency in data envelpoment analysis. *European Journal of Operational Research, 143*, 32-41.

Tone, K. (2010). Variations on the theme of slacks-based measure of efficiency in DEA. *European Journal of Operational Research, 200*(3), 901-907.

Tone, K., & Tsutsui, M. (2009). Network DEA: a slacks-based measure approach. *European Journal of Operational Research, 197*(1), 243-252.

Tone, K., & Tsutsui, M. (2010). An epsilon-based measure of efficiency in DEA–a third pole of technical efficiency. *European Journal of Operational Research, 207*(3), 1554-1563.

Wilson, P. W. (2008). FEAR: A software package for frontier efficiency analysis with R. *Socio-Economic Planning Sciences, 42*(4), 247-254.

Appendix A: DEA Software Models

Models	DEA-Solver	Frontier Analyst	DEA Frontier	MaxDEA Pro	PIM-DEA	FEAR	DEAP	EMS
CCR/CRS	y	Y	y	y	y	y	y	y
BCC/VRS	y	Y	y	y	y	y	y	y
NIRS,NDRS,GRS	y	N	y	y	y	y	n	y
Additive/Slack-Based Method	y	N	y	y	n	n	n	y
Malmquist	y	y	y	y	y	y	y	y
Non-convex	y	n	y	n	n	n	n	y
Non-radial	y	n	y	y	n	n	n	n
Preference-structure	n	n	y	y	n	n	n	n
Undesirable-measure	n	n	y	y	n	n	n	n
Context-dependent	n	n	y	y	n	n	n	n
Free-disposal hull (FDH)	y	n	y	y	n	y	n	y
Order m efficiency	n	n	n	n	n	y	n	n
Allocative efficiency	n	n	n	n	y	n	n	n
Cost efficiency	y	n	y	y	y	y	y	n
Revenue efficiency	y	n	y	y	n	y	n	n
Profit, revenue/cost efficiency	y	n	y	y	n	y	n	n
Variable-benchmark	n	n	y	y	n	n	n	n
Fixed-benchmark	n	n	y	y	n	n	n	n
Minimum-efficiency	n	n	y	y	n	n	n	n
Weak disposability	n	n	y	y	n	n	n	n
Congestion	y	n	y	n	n	n	n	n
Super Efficiency	n	n	y	y	n	n	n	n
Scale elasticity	y	n	n	n	y	n	y	n
Slack-Based Super Efficiency	n	n	y	n	n	n	n	n
Bootstrapping	n	n	y	y	y	y	n	n
Network	n	n	n	y	n	n	n	n
Dynamic	n	n	n	y	n	n	n	n
Cross Efficiency	n	n	y	y	n	n	n	n
Epsilon-Based Measure (EBM)	n	n	n	y	n	n	n	n
Restricted multiplier	n	n	y	y	n	n	n	n

y = available; n = not available