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Editorial

The 2002 International DEA Symposium, with the theme 'Efficiency and Productivity Analysis in the 21st Century', was held in Moscow from 24–26, June 2002. The Symposium was organized jointly by the Institute for Systems Analysis of the Russian Academy of Sciences and the *Global S. Consulting* Company. Approximately 100 participants from 26 countries spread over five continents were welcomed by:

- the Governor of the Moscow Region, Boris Gromov, who wished them fruitful work and expressed his confidence that the technologies discussed at the Symposium would be claimed by enterprises of both the Moscow Region and Russia as a whole;
- the Chairman of Moscow City Duma, Vladimir Platonov, who pointed out that the introduction of modern scientific technologies into the state management system was a serious challenge demanding joint efforts of politicians and scientists;
- the Director of the Institute for Systems Analysis, Professor Yuri Popkov.

Although probably originating in the work of Farrell,[1] the DEA approach as we now know it was brought into being by the publication in 1978 of a paper by Charnes *et al*.[2] This article extended the usual concept of efficiency measurement in one-input/one-output situations to include multiple inputs and outputs. As the current DEA literature shows, the ideas contained in the DEA approach have turned out to be much more seminal and far-reaching than the simple computation of the efficiency of production. It has become clear that DEA can facilitate not only the calculation of efficiency scores but also a more thorough analysis of the behaviour of production units in their context. The further development of DEA is taking several paths. For example, there appear new and more sophisticated models to describe and understand more adequately the behaviour of complex objects. Also the application of the underlying ideas, often in combination with other approaches, extends into situations that do not at first sight have connotations of production. The 60 or so papers and keynote presentations delivered at the Symposium amply demonstrated these developments. This (part) Special Issue contains eight of the papers and keynote presentations; others still under review will be published in a later (part) Special Issue of the Journal.

Scale elasticity plays an important role in the theory and practice of economics. In numerous articles and textbooks on economics, scale elasticity is described and determined in multi-input/one-output situations using a parametric production function. Neoclassical production theory has extended the production function notion to multi-input/multi-output situations where the production function is now a transformation function. This function is assumed to be continuously differentiable and there are standard procedures for analysing the scale properties of this function. However there are some difficulties in computing scale elasticity in DEA models because: (a) the transformation function is not determined explicitly, (b) the transformation function is not differentiable everywhere and (c) not all production units are considered efficient. The paper by Førsund and Hjalmarsson reviews work on scale elasticity in DEA models and they introduce and prove formulae for calculating scale elasticity for inefficient units by radial projection to the efficient frontier in either input-reducing or output-increasing orientations. More than that, for inefficient units, the paper gives a quantitative range of scale elasticity values, which provides more information to decision-makers. Førsund and Hjalmarsson thereby establish firmly the concept of scale elasticity, as defined within the production theory of neoclassical economics, for DEA models with piecewise linear frontiers.

The paper by Brockett *et al* builds on two earlier regression-based studies of the effectiveness of advertising on military recruitment by combining a regression-based approach with DEA. These earlier studies had been somewhat conflicting in their findings concerning the relative effectiveness of service-specific advertising as compared with more generic advertising. Brockett *et al* note that the estimated coefficients in regression analysis cannot be interpreted as elasticities, as defined in economics, because of the effect of technical inefficiency. However, in their study, the authors show that DEA and regression analysis can be used in a complementary fashion. First, they employ DEA to identify the efficient and inefficient units. Secondly, they incorporate dummy variables to represent this efficiency classification in a regression model. This synergistic partnership between DEA and regression analysis enabled the authors to disentangle the differential effects of the two advertising modes within an overall advertising strategy.

In their paper, Krivonozhko *et al* develop a family of parametric optimization methods that allow one to construct an intersection of the efficient frontier with a two-dimensional plane determined by any pair of given directions. This approach reduces the efficiency analysis of production units to the investigation of well-known functions in economics,

such as: production function, isoquant, isocost, isoprofit, etc. From the very beginning, DEA touched on the problem of calculating partial derivatives employed in mathematical economics, using optimal dual variables for this purpose. However, it was also noted that partial derivatives are not defined at points of the intersection of two or more bounding surface segments. Krivonozhko *et al* show that one-side directional derivatives do exist at any point of the frontier and in any direction. A constructive technique is proposed that allows the calculation of such partial derivatives and the paper demonstrates how these parametric methods can be exploited for an analysis of DEA results.

Green and Cook's paper presents an adaptation of the Free Disposal Hull (FDH) model. The FDH production possibility set, when represented within a DEA framework, ensures that the efficiency of a production unit is measured against an actually observed performance, that is that of a specific efficient production unit, rather than against a 'synthetic' production unit obtained as a linear/convex combination of a number of efficient production units. However, as is well known, apparently efficient production units can be considerably more numerous than would be the case with a 'larger' production possibility set. Green and Cook suggest expanding the FDH production possibility set by including composite production units obtained by simple aggregation of observed units. They call this expanded production possibility set the Free Coordination Hull in the sense that these composites can be regarded as real units which are coordinating the activities of their constituent units at no cost.

Lee *et al* make a connection between the production ideas of DEA and consumer-demand theory. Estimating consumers' willingness to pay for improvements in the quality of multi-attribute goods is very important for the producers of those goods, since this enables the producers to know as to which quality attributes of their products are valued most by customers and at how much. Consumers can be viewed as 'production units' where the prices they pay for multi-attribute products are the sole input, while the set of attributes they derive from the purchase are the outputs. The authors employ a DEA framework in order to estimate consumption inefficiency levels and the slope of a 'price-quality' frontier. It can be shown that the derivatives of this frontier with respect to the attributes are equal to consumers' marginal willingness to pay for the attributes. Lee *et al* apply their methodology to the case of the Korean mobile phone market. They estimate the importance of eight technological attributes of mobile phones in terms of consumers' willingness to pay for unit improvements along the products' quality dimensions.

Changes in the structure of the US health care industry have forced decision-makers to look for ways for providers to become more productive and cost efficient. This is the context for the paper by Ferrier and Valdmanis where the authors explore hospital mergers by using DEA to generate both efficiency and productivity measures to ascertain whether performance gains ensue. A comparison of DEA efficiency scores and Malmquist index values across merged hospitals and unmerged control hospitals within a quasi-experimental design allow the authors to assess whether any apparent increase in productivity is the result of a merger.

Malmquist indexes are used to estimate technical change over time. The conventional Malmquist index approach is based on radial expansion/contraction and is only able to offer an average measure of technical change. Technical change has traditionally been assumed to affect all outputs/inputs equally. In their paper, Herrero and Pascoe remark that in many production processes this is not a valid assumption, and it may be more appropriate to focus on individual outputs/inputs rather than on the average effect. They therefore propose an alternative procedure for calculating technical change, the modified Quasi-Malmquist index, that enables the estimation not only of average technical change, but also the degree to which each of the different outputs/inputs are involved.

Classic DEA models compute radial projections of production units against the efficient frontier. However, from a managerial point of view non-radial projections might be considered more useful in many practical situations. Lins *et al* explore this idea within a multi-objective approach that incorporates *a posteriori* preferences through individual projections of each variable (input or output) as an objective function. This allows them to obtain a target at every extreme-efficient point on the frontier. They show that their approach is equivalent to a preference structure model and they apply their approach to the efficiency analysis of the Public Health System in Brazil.

In conclusion, the guest editors would like to acknowledge the efforts of all the referees who reviewed these papers, Christine Faulkner and Sarah Parry (Editorial Administrators for the Journal), John Wilson (Co-Editor) and A Emrouznejad, RH Green and VE Krivonozhko (Guest Editors).

Editors' note

In addition to the eight papers discussed above, we have included in this issue of the journal two further papers on DEA. These were not papers presented at the Symposium, but we feel they fit well with the themes introduced by the other papers from the Symposium and are please to include them. The first of these papers is by Fukuyama and Weber and the second is by Silva Portela, Thanassoulis and Simpson.

Terry Williams
John Wilson

References

1 Farrell MJ (1957). The measurement of productive efficiency. *J Roy Statist Soc, Ser A* **120**: 253–290.
2 Charnes A, Cooper WW and Rhodes E (1978). Measuring the efficiency of decision making units. *Eur J Opl Res* **2**: 429–444.