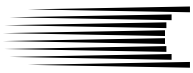

New Books in Review

AN INTRODUCTION TO DATA ENVELOPMENT ANALYSIS, R. Ramanathan, Thousand Oaks, CA: Sage Publications, 2003, 203 pages, $29.95.

NEW EFFICIENCY THEORY: WITH APPLICATIONS OF DATA ENVELOPMENT ANALYSIS, Jati K. Sengupta, New York: Springer, 2003, 175 pages, $89.95.

QUANTITATIVE MODELS FOR PERFORMANCE EVALUATION AND BENCHMARKING: DATA ENVELOPMENT ANALYSIS WITH SPREADSHEETS AND DEA EXCEL SOLVER, Joe Zhu, Norwell, MA: Kluwer Academic Publishers Group, 2003, 293 pages, $198.00.

DATA ENVELOPMENT ANALYSIS: A MANAGEMENT SCIENCE TOOL FOR SCIENTIFIC MARKETING RESEARCH

Marketing has a tradition in conducting scientific research with cutting-edge techniques developed in management science, such as data envelopment analysis (DEA) (Charnes et al. 1985). Two decades ago, Kamakura, Ratchford, and Agrawal (1988) applied DEA to examine market efficiency and consumer welfare loss. In this review of three new books, my purpose is (1) to provide a background of DEA for marketing scholars and executives and (2) to motivate them with exciting DEA advances for marketing theory and practice.

All three books provide brief descriptions of DEA's history, origin, and basic models. For beginners, Ramanathan's work, *An Introduction to Data Envelopment Analysis*, is a good source, offering basic concepts of DEA's efficiency and programming formulations in a straightforward manner (with some illustrations) in the first three chapters. A unique feature of this book is that it dedicates a chapter to discussing as many as 11 DEA computer software programs and explaining some noncommercial DEA packages that are available free on the Internet for academic purposes. As Ramanathan states (p. 111), "[I]n this computer era, it is important that any management science technique has adequate software support so that potential users are encouraged to use it. Software harnesses the computing power of [personal computers] for use in practical decision-making situations. It can also expedite the implementation of a method."

For readers who are more interested in theory of firm efficiency and industry equilibrium, Sengupta's *New Efficiency Theory* is excellent and stimulating reading. Sengupta writes in a management science–oriented style, which relatively experienced DEA researchers will appreciate. Reflecting his more than five years of research, the new DEA models that Sengupta discusses incorporate "asymmetric information in a principal-agent problem" (p. 5), "dynamic and stochastic aspects in time-series data" (p. 11), and relevant applications in the U.S. computer industry and mutual funds from a game theory standpoint. Distinguished points of this book are that it (1) addresses both level efficiency and growth efficiency in a dynamic, time-series setting; (2) examines the role of uncertainty and risk of market demand and prices; and (3) investigates resource sharing in horizontal strategic alliances "comprising firms of the same stage of production" (p. 146).

Of the three books, Zhu's *Quantitative Models* is the most comprehensive, but unfortunately it also is the most expensive. This book is truly managerially oriented. It is not difficult for executives to find that the far-reaching topics and down-to-earth applications are readily applicable to marketing phenomena. Zhu's simple approach of using Microsoft Excel 97 or later versions rather than sophisticated modeling programs makes it convenient for managers to apply DEA models in benchmarking (though this approach could be laborious and lengthy with a large sample size). Other topics addressed include the value chain efficiency (Chap. 8), context-dependent relative attractiveness (Chap. 6), and congestion measures (Chap. 9), all of which Zhu and his mentor Lawrence M. Seiford originally developed and have published in their coauthored journal articles. *Quantitative Models* comes with DEA Excel Solver software, which is preprogrammed with a wide variety of DEA models.

All three books provide distinct insights into the concepts, models, and applications of DEA. They are written for general audience, not solely for mathematicians. Whereas Ramanathan offers a basic overview for new DEA researchers, Sengupta and Zhu complement each other's work in advanced DEA applications for experienced readers. Sengupta focuses on unconventional DEA fronts such as dynamic and stochastic aspects, whereas Zhu tends to emphasize traditional DEA models with truly innovative interpretations and manipulations.

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DEA Efficiency and Microeconomic Theory

The roots of DEA are in microeconomic theory. It uses the optimization method of linear programming to generalize from Farrell's (1957) single output/input efficiency measure to the multiple outputs/inputs efficiency measure. In addition, DEA optimizes on each individual observation and provides a ratio score to indicate relative efficiency performance against the set of Pareto-efficient frontiers. An efficient observation is one for which no other observations, or linear combination of observations, in the sample generate as much as or more outputs given the level of inputs (or consume as much as or less inputs given the level of outputs). As Charnes, Cooper, and Seiford (1994, p. 8) note in their milestone work, DEA is best characterized by the following:

- A focus on individual observations in contrast to population average;
- Production of a single aggregate measure for each decision-making unit (DMU) in terms of its use of input factors (independent variables) to produce desired outputs (dependent variables);
- Simultaneous use of multiple outputs and multiple inputs, where each is stated in different units of measurement;
- Ability to adjust for exogenous variables;
- Ability to incorporate categorical (dummy) variables;
- No required specification or knowledge of a priori weights or prices for the inputs or outputs and value free;
- No restrictions on the functional form of the production relationship;
- Ability to accommodate judgment when desired;
- Production of specific estimates for desired changes in inputs and/or outputs for projecting DMUs below the efficient frontier onto the efficient frontier;
- Pareto optimal;
- A focus on revealed best-practice frontiers rather than central-tendency properties of frontiers; and
- Satisfaction of strict equity criteria in the relative evaluation of each DMU.

The beginnings of DEA were with Edwardo Rhodes's dissertation work at Carnegie Mellon University, under the supervision of W.W. Cooper (Charnes, Cooper, and Rhodes 1978). In the past 26 years, more than 2000 articles on DEA have been published in economics, sociology, strategy, marketing, and many other disciplines.

Why has DEA been so popular among scholars and managers? Zhu argues that DEA's managerial relevance and advantages over traditional benchmarking measures are critical to answering this question. According to microeconomics, to improve performance, a firm must constantly evaluate and benchmark processes related to producing marketable products, providing customer services, and marketing and selling products. Zhu notes (p. xxi) that such benchmarking is a "widely used method to identify and adopt best practices as a means to improve performance and increase productivity." However, traditional single-measurement benchmarking (e.g., profitability ratio, financial leverage) can be limited and difficult to implement. First, real-world businesses often face multiple inputs (e.g., labor, machines, intangible resources) and multiple outputs (e.g., customer satisfaction, market share, profitability) rather than a single output or single input. The return on investment measure may capture financial performance, but it is not a satisfactory discriminant of "best practice" to evaluate operating efficiency or customer management efficiency. Second, "the use of single measures ignores any interactions, substitutions, or trade-offs among various performance measures" (p. 2), which neglects an important aspect of the microeconomic theory of resource substitutions.

The advantages of DEA are more apparent in evaluations of the performance of the public sector, such as schools, universities, and government agencies. For public-sector enterprises, output and input prices are often unavailable, and thus outputs and inputs cannot be weighted with a priori function to calculate the efficiency ratio. This explains the high-volume, widespread DEA applications that mainly were in the public sector in the 1980s, during the so-called first phrase of Sengupta's DEA research (p. 10).

Given recent extensions of efficiency theory since the 1990s, DEA has advanced from a focus on technical or production efficiency (the firm's success in producing maximum outputs given the inputs) in the public sector to an emphasis on the importance of allocative or price efficiency (the firm's success in choosing an optimal set of inputs given the input prices determined by the market) in the public and private sectors. Consider the following statements from Sengupta's work (p. 11):

> The second phase considered applications in the private sector such as commercial banking, airlines, and transportation industries, where market prices determined by competitive markets played an active role. This phase emphasized more on the cost frontier than the production frontier, and hence price cost data proved to be equally important as the physical input output data.
>
> The third phase considered various types of dynamic and stochastic aspects associated with technical and allocative efficiency. Dynamic aspects involve time series data on inputs, outputs, and prices, which may involve a short or a long run production horizon. Output growth over time may be due to input growth and price changes over time. In this growth perspective one may distinguish between level efficiency and growth efficiency. The former relates output levels to inputs, whereas the latter explains output growth by input growth. Thus the former yields technical level efficiency, whereas the latter technical growth efficiency.

Data envelopment analysis fits well with current business practices of cost cutting and downsizing during economic recession (or during weak growth). Today, increased global competition and business costs, as well as reduced marketing and selling budgets, require firms' marketing functions to be more efficient and productive. Grounded in microeconomic theory, DEA efficiency provides guidelines and benchmarks for both public and private enterprises to achieve maximized desirable ends at minimized costs. In this sense, it is no wonder that DEA has been so popular among marketers and scholars. Particularly for marketing researchers, DEA offers some important implications, which I discuss next.

DEA Implications for Marketing Research

In promising the possible interactions between management science and marketing research, Charnes and colleagues (1985, p. 101) note that "recent research in management science has developed an approach called DEA, which

opens new alternatives for marketing management." Indeed, DEA offers enormous implications for marketing research in behavioral (e.g., consumer), managerial (e.g., advertising, retailing, sales, strategy), and quantitative (e.g., marketing models) areas.

In the consumer domain, DEA may enhance the understanding of market efficiency. Academics can use it to test modern economic theory on brand efficiency (i.e., Will all brands in a competitive market with perfect or costless information be efficient? see Kamakura, Ratchford, and Agrawal 1988) and market efficiency (i.e., How well do consumer markets function, or is price a good signal of quality? see Ratchford et al. 1996). Because the core of firms' marketing is attracting and retaining customers, DEA may be essential to examining marketing accountability in terms of customer efficiency (i.e., the degree to which customers use inputs to produce at least the same amount of outputs; see Xue and Harker 2002). In this sense, both Zhu and Sengupta provide insights into the customer service delivery process (two-stage or multistage DEA) and the contingent role of uncertain market demand and prices (stochastic DEA).

In the managerial domain, practitioners and academics have long been frustrated by as high as 50% inefficient media spending and misallocation of advertising budgets. In these cases, DEA can be used to benchmark marketers' advertising efficiency in generating firm sales and profits (Luo and Donthu 2001, 2004). For retail chain stores and franchise systems, DEA offers managers a tool for measuring the comparative (relative-to-best) performance of outlets (Donthu and Yoo 1998; Kamakura et al. 2002). In the personal selling area, because sales force compensation is often based on performance evaluation, an unbiased measurement of salesperson performance is critical; the application of DEA generates a fair performance evaluation for salespeople (Boles, Donthu, and Lohtia 1995). At the strategy level, DEA has critical implications in controlling for observed and unobserved managerial skills in predicting first-mover market-share advantages (Murthi, Srinivasan, and Kalyanaram 1996) and in assessing the relative efficiency of the selling and marketing function (Mahajan 1991).

In building innovative marketing models, Horsky and Nelson (1996) demonstrate the relevance of DEA. They suggest a top-down approach to assess efficiency at the sales-district level by developing a DEA-efficient frontier to estimate the relationship between total district sales and sales force size, efforts, and district competition. In addition, Thomas and colleagues (1998) juxtapose DEA models with assurance regions in a Delphi approach to develop an interesting research process for the evaluation of store efficiency.

DEA Future and Scientific Marketing Research

Before I turn to the future of DEA, several important caveats of DEA should be noted, though Ramanathan, Sengupta, and Zhu all chose not to mention potential limitations. First, it is likely that DEA fails to discriminate the relative performance of observations; all observations could be classified as efficient (e.g., when the number of observations is less than three times the number of input and output variables). Second, DEA calculations are not free from common programming problems, such as alternate optima, degeneracy, and cycling; thus, this likely leads to confounding efficiency results for decision making. Third, a firm may be classified as efficient merely because it is different from other firms. Perhaps the strongest criticism of DEA is that it is highly sensitive to errors in data. Conventional DEA models unrealistically assume that the analyzed data have no measurement error or unsystematic noise (Charnes, Cooper, and Seiford 1994; Luo and Donthu 2004).

Given the exponentially increasing number of DEA articles recently, the future of DEA is unquestionably rosy. Sengupta makes a significant stride in extending DEA research nonconventionally; he examines stochastic DEA that incorporates asymmetric information, demand uncertainty, and input sharing. Besides documenting basic and recent developments in DEA (e.g., window analysis) as Ramanathan does, Zhu explains that even traditional DEA models can be interpreted in many novel ways, which also contributes substantially to the literature.

The attention given to DEA in marketing is not commensurate with its potential importance (Charnes et al. 1985). Marketing scholars should devote more attention to the application of DEA; it could greatly benefit scientific marketing research and practice on a variety of subjects (e.g., customer relationship management, business to business, strategy, modeling). For example, to ensure the success of customer relationship management in enhancing firm profitability, researchers could evaluate and boost customer efficiency in the process of transaction, value creation, and quality delivery while protecting consumer welfare. Zhu's DEA models for the evaluation of value chains are critical to the understanding of the efficiency of a supply chain system (including suppliers, manufactures, retailers) in business-to-business marketing.

An exciting direction for the application of DEA is the examination of the performance of marketing functions from a strategic, dynamic-capability standpoint. That is, DEA can readily assess a firm's dynamic capability to deploy marketing knowledge and skills in customer–firm interactions to achieve a desired end. In this sense, DEA uncovers the "black box" of transformation process (from marketing inputs/resources to marketing outputs/outcomes). In terms of marketing modeling, the window analysis and Malmquist productivity index, which Ramanathan mentions, and the concept of growth efficiency, which Sengupta mentions, are applicable to scanner data and firm longitudinal data in PIMS or Compustat to evaluate customer brand loyalty and marketing's contribution to organizational financial performance over time. Marketing researchers who are interested in mediated and moderated relationships may also find Zhu's work on the multistage DEA (identifying possible mediating results) and context-dependent DEA (identifying possible moderating results) intriguing and, conceivably, breathtaking.

The three books definitely address the topic well, if not perfectly. I recommend Ramanathan's book for MBA students and executives, whereas Sengupta's and Zhu's books would be excellent choices for doctoral marketing-modeling class participants and experienced marketing researchers. I hope that marketing scholars are motivated by these three books to publish a new DEA book specifically and exclusively for scientific marketing research.

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REFERENCES

Boles, James S., Naveen Donthu, and Ritu Lohtia (1995), "Salesperson Evaluation Using Relative Performance Efficiency: The Application of Data Envelopment Analysis," *Journal of Personal Selling & Sales Management*, 15 (Summer), 38–49.

Charnes, Abraham, William W. Cooper, D.B. Learner, and F.Y. Philips (1985), "Management Science and Marketing Management," *Journal of Marketing*, 49 (Spring), 93–105.

———, ———, and Edwardo Rhodes (1978), "Measuring the Efficiency of Decision Making Units," *European Journal of Operational Research*, 3 (4), 429–44.

———, ———, and L. Seiford (1994), *Data Envelopment Analysis: Theory, Methodology, and Applications*. Boston: Kluwer Academic Publishers.

Donthu, Naveen and Boonghee Yoo (1998), "Productivity Assessment Using Data Envelopment Analysis," *Journal of Retailing*, 74 (Spring), 89–117.

Farrell, M.J. (1957), "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society*, 120 (3), 253–81.

Horsky, Dan and Paul Nelson (1996), "Evaluation of Salesforce Size and Productivity Through Efficient Frontier Benchmarking," *Marketing Science*, 15 (4), 301–320.

Kamakura, Wagner A., Vikas Mittal, Fernando de Rosa, and José Afonso Mazzon (2002), "Assessing the Service-Profit Chain," *Marketing Science*, 21 (Summer), 294–317.

———, Brian T. Ratchford, and Jagdish Agrawal (1988), "Measuring Market Efficiency and Welfare Loss," *Journal of Consumer Research*, 15 (December), 289–302.

Luo, Xueming and Naveen Donthu (2001), "Benchmarking Advertising Efficiency," *Journal of Advertising Research*, 41 (6), 7–18.

——— and ——— (2004), "Using Non-Parametric and Parametric Best Practices Methods to Assess Advertising Media Spending Inefficiency," *Journal of Business Research*, 57, forthcoming.

Mahajan, Jayashree (1991), "A Data Envelopment Analysis Model for Assessing the Relative Efficiency of the Selling Function," *European Journal of Operational Research*, 53 (2), 189–205.

Murthi, B.P.S., Kannan Srinivasan, and Gurumurthy Kalyanaram (1996), "Controlling for Observed and Unobserved Managerial Skills in Determining First-Mover Market Share Advantages," *Journal of Marketing Research*, 33 (August), 329–37.

Ratchford, Brian T., Jagdish Agrawal, Pamela E. Grimm, and N. Srinivasan (1996), "Toward Understanding the Measurement of Market Efficiency," *Journal of Public Policy & Marketing*, 15 (Fall), 167–84.

Thomas, Rhonda R., Richard Barr, William Cron, and John Slocum (1998), "A Process for Evaluating Retail Store Efficiency: A Restricted DEA Approach," *International Journal of Research in Marketing*, 15 (4), 487–503.

Xue, Mei and Patrick T. Harker (2002), "Customer Efficiency: Concept and Its Impact on E-Business Management," *Journal of Service Research*, 4 (4), 253–67.