Using Mathematical Programming to Assess the Relative Performance of the Health Care Industry

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Unlike conventional methods for evaluating program efficiency, a recently developed mathematical programming technique, Data Envelopment Analysis (DEA), is able to handle multiple inputs and outputs simultaneously without assigning arbitrary weights and does not require the use of homogeneous measurement units nor a prespecified functional relationship between inputs and outputs. Despite of its unfamiliarity to health care researchers and administrators, this technique is becoming increasingly popular as a means of evaluating relative performance in not-for-profit entities.

INTRODUCTION

Due to resource constraints, an ongoing problem in not-for-profit public services is how to allocate resources efficiently and equitably. Most existing resource allocation methods are based on community need, population served, and some unspecific political concerns. Many investigations concern equity of health care services distribution, rather than efficiency and effectiveness of their performance. While there is pressure to allocate limited resources to the more efficient and effective health services, the measurement of efficiency and effectiveness is difficult due to the absence of an analog for profit-seeking behavior and difficulties in specifying technical capacities through engineering studies. These difficulties have been recognized in the health care industry for years, even though some health care organizations have become proprietary or profit-oriented. The most common problem encountered in the evaluation of the health care industry is how to measure its performance that involves multiple inputs and produces multiple outputs, especially considering the basic difficulties in identifying and measuring its inputs and outputs.

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LIMITATIONS IN CONVENTIONAL METHODS

Most existing evaluative measurement techniques in not-for-profit entities rely on ratio analysis and regression analysis. However, both methods have their limitations.

Two of the most commonly used evaluative methods are cost-benefit and cost-effectiveness analyses. Though impacted by social values, they usually deal only with comparisons of single variables, assuming other variables (such as case mix and patient characteristics) are constant or of minor importance. For example, a common measure of such analyses in program evaluation is the ratio of a single output over total monetary inputs (e.g., 1 life saved per $1000 spent in a health promotion program) or costs per output unit (e.g., average costs of $5000 per hospital admission.) The requirement of the use of homogeneous measurement units, which requires transforming all inputs and/or outputs into monetary units, has been strongly criticized. Not only is the identification and measurement of inputs and outputs difficult, but the transformation also requires technical sophistication which may not be available to evaluators, or may be unnecessary. Also, political or moral controversies that result from placing economic values on a particular input or output could obscure the relevance and defer its potential utility. These limitations are well acknowledged by even the strongest advocates of cost-benefit analysis.

Difficulties also appear when multiple input and/or output variables are necessary and have inconsistent indications. For example, in the evaluation of hospital performance, some hospitals may have lower obstetric costs, but higher surgical costs compared to those in some other hospitals. Therefore, comparison of the overall performance between two hospitals becomes controversial. Further comparisons of multiple outputs via ratio analysis require a priori weights and/or a standardizing measurement to get an overall output measure (indicator). The arbitrariness and predetermination of these weights and standardization have often been questioned.

Another common method used in evaluation is least-squares regression analysis. This method provides estimates of average (or central tendency) input-output relationships based on data of both efficient and inefficient units. Therefore, ordinary least-squares regressions may provide good predictions of what costs will be, "assuming a constant level of inefficiency, but they say nothing about efficiency relationships." The criteria set to distinguish efficiency from inefficiency are accordingly arbitrary and questionable. Although some advanced econometric methods can measure the efficient frontier, the statistical methods applied make it difficult to take multiple outputs into account simultaneously. Additionally, regressions require a fixed input-output functional relationship to be determined beforehand which makes the evaluation more difficult to be implemented and understood. Moreover, the results of the aggregated estimates from regression may not be so useful to managers who oversee day-to-day operations.

AN OVERVIEW OF THE NEW TECHNIQUE—DEA

"Data Envelopment Analysis" (DEA) is a mathematical programming technique development by Charnes, Cooper, and Rhodes in 1978 to overcome the above deficiencies. Since then, the DEA has been advanced as a more appropriate method and has become popular in evaluating relative performance of not-for-profit organizations. Unlike conventional evaluation methods, the DEA technique is able to handle multiple inputs and