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Original Article

Measuring Technical Efficiency of Schools in Tehran University of Medical Sciences Using Data Envelopment Analysis

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ABSTRACT

Background: Organizational efficiency should be continuously measured to plan for improvement, informing about organizational performance, and guiding the university toward its goals. In this study, the authors measured the efficiency of schools affiliated to Tehran University of Medical Sciences as one of the most important universities in Iran, in 2011 and 2012.
Methods: In this research, the efficiency of schools was measured using data envelopment analysis (DEA) technique in three dimensions of education, research, and development. Several indices in each dimension were assumed as input. Data were collected from university documents and analyzed by output oriented approach using DEAP software version 2.1.
Results: Findings revealed that the efficiency scores of four schools including public health, pharmacy, nursing and midwifery, and advanced technologies were 100 in both years. In 2011, the efficiency scores for other schools were as follows: medicine 73.1, dentistry 57.6, rehabilitation 82.33, paramedical sciences 80.26, and management and medical information 60.26. These scores were respectively 73.76, 85.26, 71.63, 94.16, and 94.86 in 2012.
Conclusion: This research could successfully measure the efficiency of schools. Moreover, it can help decision makers to improve the performance of schools by determining the optimized output.
Keywords: Education, Efficiency, Iran, Research, Universities
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Introduction

One of the key roles of managers is to ensure long-term success and survival of the organization. In this regard, concepts such as efficiency and effectiveness help the managers of the organization to measure and compare the success rate of their efforts in achieving goals. The managers should be able to review and interpret the performance of their organization. Measuring efficiency is one of the most effective and integral parts of management (1). Measuring efficiency can provide useful information about the strengths and weaknesses of an organization so as to improve and reform a system (2-4).

Efficiency as a criterion shows the proper use of the production factors and resources. In other words, efficiency shows how the work that is being done can achieve higher results at lower costs with fewer facilities, maximize the use of existing forces, and prevent the waste of material and human resources. Therefore, studying the changes in the trend of efficiency can help one to identify the weaknesses of different parts of an organization and plan to improve the performance and develop of the organization (5-7). Any dynamic educational system needs evaluation for an effective engagement with changes (8). However, measuring the efficiency of the public sector, especially in providing services such as universities, is a complex issue (9). Measuring the efficiency of schools is part of the difficult process of allocating resources in universities (8). Universities, as organizations that target the training of professional human resources along with science production, require measuring the efficiency of its decision-making units (DMUs) i.e. schools and departments, more than any other organization (9).

With the increasing competition in the educational and research fields, organizations need indices and patterns to assess their DMUs. The weakness of traditional measurement criteria and the changing competitive environment indicate the need for redesigning efficiency measurement systems in organizations (1,10,11). Furthermore, a continuous process of intradepartmental cross-evaluations exists in universities usually based on academic values that assess the quantity and quality of a department in terms of education, research, and development of services; the results, however, might significantly vary among reviewers (10).

Given the inherent limitations of traditional methods for efficiency measurement, a comprehensive and systematic tool specifically designed for higher education evaluation should be used (12). Some commonly used methods for efficiency measurement include Data Envelopment Analysis (DEA), Analytic Hierarchy Process (AHP), and Analytical Network Process (ANP) (13). DEA is one of the successful tools in implementing strategic organization plans to achieve a new efficiency measurement system (8,9,11). Efficiency measurement by DEA was introduced by Charnes and Cooper in 1978 (14). DEA was initially used as a tool for efficiency measurement of organizations such as social services that did not have incentives for profitability (8, 15). DEA has so far played an important role in efficiency measurement of organizations, hospitals, and universities (8,11,16-18). DEA can monitor the inputs, outputs, and educational, research, and development processes of universities (1,10,11). This method can identify efficient and inefficient units, inform university schools of their weaknesses, and help them eliminate their weaknesses by seeking help from the efficient units and following their model. Furthermore, DEA creates a sense of competition among the schools, which will ultimately advance the university (1, 19). DEA can almost fully guarantee the rating of DMUs (20), and help decision makers to have a detailed comprehensive view of the performance of different schools of a university (21). A DEA study can be used as a tool for comparing strategies and to help improve the performance of an educational institution. An important feature of DEA is the findings that can support the optimal use of resources in organizations with different missions. Organizations and universities can be compared by how they manage their resources and achieve the goals (12). Previous studies at university level, efficiency indices were classified in terms of education, research, and development (1, 10, 12, 22, 23).

In this regard, this study aimed to measure and compare the efficiency of the schools of Tehran University of Medical Sciences as the largest medical university in Iran in order to precisely evaluate its performance. The efficiency of these schools has been presented in three dimensions of education, research, and development using DEA in 2011 and 2012.

Methods

This descriptive cross-sectional study was conducted in two phases to measure technical efficiency of the schools of Tehran University of Medical Sciences, using DEA in 2011 and 2012. At the first phase, information was gathered to identify the indices from deans of departments and deputies of schools. At the second phase, the information about each index was comparatively assessed based on the collected data among schools in three domains of education, research and development. At this phase of the study, the schools of Tehran University of Medical Sciences formed the study population. The examined schools in two years of the study included the schools of public health, pharmacy, medicine, dentistry, rehabilitation, nursing and midwifery, paramedical sciences, advanced technologies in medicine, and health management & information sciences. Two schools of traditional medicine and nutritional sciences were not studied as they were newly established and had no data in one or both of the study years.

The selected indices for determining the efficiency were selected according to the common performance areas of the schools and according to the opinion of the deans of schools and departments, and the education and research deputies of schools. This allowed for a comparison among the schools. Based on literature review, we identified the indices used for measuring efficiency and effectiveness. Then, based on these indices, a questionnaire was developed and the opinions of deans of schools, department, and deputies of education and research were sought about the importance of each of these indices. After the final analysis of the questionnaires, a list of indices whose data were available selected as inputs and outputs in three dimensions of education, research, and development. The data for each index in 2011 and 2012 were extracted from documents such as the Statistical Yearbook of Tehran University of Medical Sciences, search in paper databases, statistics and documentation available on the

websites of the schools and the university, and in some cases through visits of schools. The final indices whose data were extracted and analyzed are as follows:

Educational indices (input)

Educational input indices included: total number of students in each school; total number of postgraduate students in each school; total number of Ph.D. students in each school; total number of residents in each school; total number of fellowship students in each school; total number of full professors in each school; total number of associate professors in each school; total number of assistant professors in each school, and total number of instructors in each school.

Educational indices (output)

Educational output indices were total number of graduates in each school; total number of postgraduate students in each school; total number of Ph.D. graduate in each school; total number of MD graduate in each school; total number of fellowship graduate in each school; total number of fields of study in each school, and total number of new fields of study/grades in each school.

Research indices (input)

Research input indices included total number of postgraduate students in each school; total number of Ph.D. students in each school; total number of residents in each school; total number of fellowship students in each school; total number of full professors in each school; number of associate professors in each school; number of assistant professors in each school, and number of instructors in each school.

Research indices (output)

Research input indices included number of articles indexed at the Web of Science database by the professors and students of each school; number of articles indexed at the Scopus database by the professors and students of each school; number of dissertations registered in each school, number of Persian and English scholarly journals of each school, and number of participants in foreign conferences.

Development indices (input)

Development inputs indices included total number of full professors in each school; number of associate professors in each school; number of assistant professors in each school, and number of instructors in each school; total number of fields of study/grades in each school.

Development indices (output)

Development output indices included number of journals approved, and number of foreign students.

The technical efficiency was estimated from and compared with the data extracted from these indices using the DEA technique.

DEA method allows the simultaneous assessment of multiple inputs and outputs with different measurement units. This feature of DEA makes the technique suitable for multi-product organizations such as universities. In addition, it is possible to use this technique to identify surplus production factors in DMUs, which are the schools' departments. DEA technique is a management method that generally generates a virtual unit with maximum efficiency by combining all the study units, and compares other inefficient units with that (24). Therefore, in this study, DEA method was used to estimate the technical efficiency of all schools of Tehran University of Medical Sciences based on maximizing output, using cross-sectional data and assuming variable return to scale (VRS). One of the main reasons for choosing this model is that the inputs are not within the control of the departments, so the input minimization model could not be used in relation to the technical efficiency measurement of the schools of the university of medical sciences (24, 25). In this model, the schools that earned a score of 100 in efficiency were considered to be efficient, and any scores less than 100 showed the amount of inefficiency. The schools had to increase their output to achieve maximum efficiency.

Given that efficiency measurement in this study was output oriented, this method was also used to determine the output shortage. This amount indicates how much of that output is needed by each school to achieve its maximum efficiency. In fact, in this method, the optimal amount of each output is specified in each school.

Technical efficiency of schools for three dimensions of education, research and development in two years of 2011 and 2012 were calculated using DEA method in the DEAP software version 2.1 (CEPA System Co., Australia) (26).

Results

Table 1 shows the technical efficiency scores of the schools of Tehran University of Medical Sciences in 2011 in three dimensions of education, research, and development.

As showed in Table 1, the educational efficiency of all schools was 100 in 2011. In the research dimension, all schools except medicine (45.0), dentistry (45.7), and health management & information sciences (52.1) earned a score of 100 in 2011.

Table 1. Technical Efficiency of the Schools of Tehran University of Medical Sciences in 2011 According to the Dimensions of Education, Research, and Development

School	Technical educational efficiency	Technical research efficiency	Technical developmental efficiency
Public health	100	100	100
Pharmacy	100	100	100
Medicine	100	45.0	74.3
Dentistry	100	45.7	27.2
Rehabilitation	100	100	47.0
Nursing & Midwifery	100	100	100
Paramedical sciences	100	100	40.8
Advanced technologies in medicine	100	100	100
Health management & information sciences	100	52.1	28.7

Table 2. Technical Efficiency of the Schools of Tehran University of Medical Sciences in 2012 According to the Dimensions of Education, Research, and Development.

School	Technical educational efficiency	Technical research efficiency	Technical developmental efficiency
Public health	100	100	100
Pharmacy	100	100	100
Medicine	100	100	61.7
Dentistry	100	100	55.8
Rehabilitation	100	68.7	52.0
Nursing & Midwifery	100	100	100
Paramedical sciences	100	100	82.5
Advanced technologies in medicine	100	100	100
Health management & information sciences	100	100	84.6

In the development dimension, the difference between schools was more than that of the education and research dimensions. Accordingly, five schools of medicine (74.3), dentistry (27.2), rehabilitation (47.0), paramedical sciences (40.8), and health management & information sciences (28.7) scored below 100 and the schools of public health, pharmacy, nursing & midwifery, and advanced technologies in medicine earned a score of 100.

Table 2 shows the technical efficiency score of the schools of Tehran University of Medical Sciences in 2012 in three dimensions of education, research, and development. As Table 2 shows, the educational efficiency of all schools was 100 in 2012, as in 2011. In the research dimension, the efficiency of all schools was 100 except rehabilitation school (68.7). In the development dimension, only the efficiency of the schools of health, pharmacy, nursing & midwifery, and advanced technologies in medicine equaled 100, and the efficiency of the schools of medicine, dentistry, rehabilitation, paramedical sciences, and health management & information sciences was 61.7, 55.8, 52, 82.5, and 84.6.

Figure 1 provides a comparison of the mean technical efficiency scores of all three dimensions of education, research, and development in the two study years. As shown, the efficiency of most schools (except rehabilitation) improved in 2012 compared to 2011. It also shows that the effectiveness of the schools of health, pharmacy, nursing & midwifery, and advanced technologies in medicine was 100 in both years.

Discussion

The continuous improvement of efficiency required for the success of each university and school is not possible without knowing the extent to which the goals are achieved, receiving feedback, assessing the degree of implementing university policies, and identifying the weak points that seriously need improvement. Efficiency improvement also requires measuring and evaluating all of the above. In other words, anything that cannot be measured may not be controlled and managed.

The schools of Tehran University of Medical Sciences need to have accurate information on the reasons for inefficiencies in education, research and development domains for further improvement of positive points and elimination of negative points. The results of this study will inform schools of the amount of optimal and potential output of their products in these three domains.

As observed in the results of the education dimension, the technical efficiency of all the schools of Tehran University of Medical Sciences was equal to 100 in 2011 and 2012. This means that all schools have successfully produced a decent level of output using specific inputs. The main reason for the equal educational efficiency of the school was their compliance with the principles and standards set by the university. For example, the school-student ratio or student-graduate ratio in all schools was predetermined, and equaled the educational efficiency of these schools. Accordingly, it can be stated that the educational efficiency of all schools of Tehran University of Medical Sciences was equal and no school had a better or worse situation than another school.

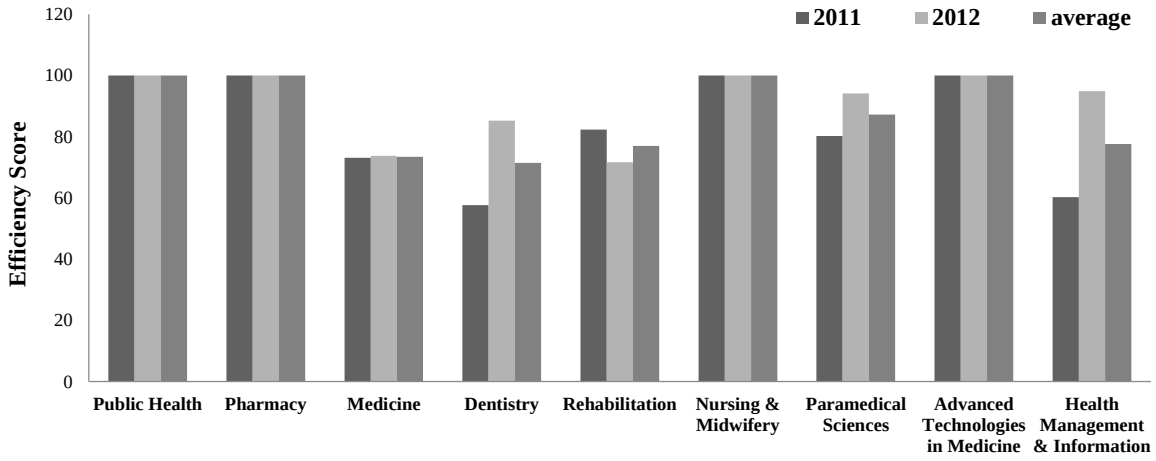

Figure 1. Mean Technical Efficiency of the Schools of Tehran University of Medical Sciences in 2011 and 2012

Determining principles and standards by the university's deputy of education in education, as well as schools' compliance with these principles and standards, are the main reason for the equal efficiency of the schools of the Tehran University of Medical Sciences.

Measuring efficiency led to the conclusion that educational ability of schools increased equally and the university succeeded in establishing equality in education among the schools of Tehran University of Medical Sciences. An interesting point is the schools' equality of efficiency in both years, which proves procedural stability in education at Tehran University of Medical Sciences.

Research dimension was somewhat different from education. As the tables related to research efficiency in 2011 and 2012 show, the efficiency score was 100 for the schools of public health, medicine, nursing & midwifery, paramedical sciences, and advanced technologies in medicine. This means that these schools, using their inputs, have been able to produce more research outputs than other schools. In 2011, the efficiency of the schools of medicine, dentistry and health management & information sciences was 45, 45.7 and 52.1, respectively. In 2012, however, the research efficiency of these three schools reached 100. The situation is, however, different in the school of rehabilitation. The research efficiency of the school of rehabilitation in 2011 was 100, which decreased to 62.9 in 2012. What is known in the general review of the efficiency of the schools of Tehran University of Medical Sciences is that in 2012, the efficiency of most schools increased compared to 2011, except for the rehabilitation school.

Improved research efficiency of the schools in 2012 compared to 2011 indicates that schools tended to level up in this regard. The fact that students need to publish a certain number of papers before defending their thesis, as well as an increasing emphasis on research can be the reasons for more convergence among the schools in terms of research efficiency in 2012 compared to 2011.

The convergent efficiency of the schools in 2012 could also indicate the efforts of the weaker schools to reach stronger ones in terms of research. Of course, the development and implementation of standards by the research deputy, such as the publication of a certain number of papers per student or professor, could be accounted for this.

The rehabilitation school was the only school that experienced a decrease in efficiency in 2012 compared to 2011. Given that the DEA technique measures performance in relative terms, it cannot be stated that its outputs decreased. Perhaps the reason for this decrease is that other schools made greater efforts and increased their research output, and that rehabilitation school was not able to perform better as compared to other schools. Table 2 indicates that the greatest shortage of rehabilitation school in 2012 was in the total number of indexed papers in Medline and Scopus, as a result, the school can make a major leap in its efficiency by increasing the number of such papers.

The results of evaluating the technical efficiency in the development dimension indicated a different situation compared to the education and research dimensions. Although in the study years, the educational efficiency of all schools was 100 and the research efficiency of most schools was 100, the situation was completely different in terms of development efficiency. According to the results in 2011 and 2012, the development efficiency of most schools was below 100, and only the schools of public health, pharmacy, nursing & midwifery, and advanced technologies in medicine had an efficiency score of 100 in both years. Of course, it should be noted that, like the research efficiency, the efficiency of the schools improved in 2012 compared to 2011, and the efficiency of the schools became more convergent and closer to 100.

In 2011, the development efficiency of the schools of dentistry and health management & information sciences was the lowest: 27.2 and 28.7, respectively. Meanwhile, the efficiency of the schools of pharmacy, rehabilitation, and medicine was 40.8, 47 and 74.3, respectively. The development efficiency of the schools dramatically improved, as it rose from the lowest score of 47 in 2011 to 52 in 2012 for rehabilitation school. The efficiency of the schools of medicine, dentistry and health management & information sciences was 61.7, 55.8, 82.5 and 84.6, respectively. Other schools, as mentioned above, had a development efficiency of 100.

The large difference among the schools in terms of development (compared to the education and research dimensions) can be attributed to the fact that the university has not set standards and principles for the development of schools, and that schools themselves have individually sought to improve the index of development. However, schools have improved their status in 2012 and have brought themselves closer to the efficiency of superior schools. The greatest leap in development efficiency was observed in the school of health management & information sciences from 28.7 in 2011 to 84.6 in 2012. Since this school was the only school working independently after the integration of Iran University of Medical Sciences in Tehran University of Medical Sciences, it is likely that the integration improved the level of development of this school and its efforts to reach the level of the top schools of Tehran University of Medical Sciences.

The study of the technical efficiency of the schools based on three domains of education, research and development showed that four schools of public health, pharmacy, nursing & midwifery, and advanced technologies in medicine experienced an efficiency of 100 in the study years. The efficiency of other schools in 2011 was 100 and the efficiency of the schools of medicine, dentistry, rehabilitation, paramedical sciences, and health management & information sciences was 731.1, 57.6, 82.33, 80.26 and 60.26, respectively. In 2012, the efficiency of all schools, except rehabilitation, had a better status and was closer to 100. The efficiency of the schools of medicine, dentistry, paramedical sciences, and health management & information sciences in 2012 was 73.76 ، 85.26, 71.63, 94.16 and 94.86, respectively. In 2012, two schools of dentistry and health management & information sciences experienced a greater leap in the technical efficiency score compared to other schools. It is noteworthy that these two schools were among the few schools that received the least impact from the integration of Iran University of Medical Sciences in Tehran University of Medical Sciences, with no changes in their structure. However, the reduction in the efficiency of the rehabilitation school in 2012 compared to

2011 should be examined more carefully and the officials of the school should discover the reason for the reduced efficiency and take required measures to improve it.

Using multiple inputs and outputs in efficiency analysis is better than traditional methods (15). DEA is used as an alternative to traditional methods to improve management performance strategies (16, 27, 28). Specifying the optimal value for each output index, DEA can help determine the best path to achieve strategic goals (22). Different types of strategies determined by DEA can provide useful information for institutions interested in pursuing goals related to excellence in education and research (12).

Conclusion

Given that efficiency measurement in this study was based on the output-centered assumption, the output shortage was also determined, which indicates the amount of output that should be increased to help the schools' deans, professors, and students to achieve maximum efficiency. In fact, in this method, the optimal amount of each output is specified in each school. DEA in this study was able to determine the optimal amount of each output index for obtaining a score of 100 for each school. The results showed schools that are further from the score of 100 need a greater improvement in their outputs. Schools that are more inefficient can significantly waste resources. Hence, the results of this study could help the schools of Tehran University of Medical Sciences to identify their weaknesses and take appropriate measures to improve their efficiency.

Details of DEA can provide the necessary information for the development of a university in a specific direction. This study opened a new window to further research that can be used to allocate resources and make decisions for senior managers of schools and universities. This study was a potential route for further research in the coming years. Observing technical efficiency in the higher education sector for several consecutive years and evaluating the efficiency of the process will develop this method in the next evaluations.

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Ethical consideration

The study protocol has been approved by Ethical Committee of Iran University of Medical Sciences.

Conflicts of interests

Authors declared no conflict of interest.

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