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Evaluating Hospital Efficiency Using DEA-MI

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ABSTRACT

Hospital efficiency analysis and performance comparison among homogeneous firms provides the field of using tools and economic indicators in health-medical management, allocation of resources and other managerial decisions. The aim of this research is measuringand identifying the productivity changes of some medical university's public. This research has done on the efficiency of 27 hospitals, using a combination of DEA and Malmquist index. Variable number of doctors, beds, nurses, paramedical personnel, outpatients, surgical patients, the mortality of patients and hospitalized days were used and data were extracted from annual reports data form health departments and analyzed with EMS software. The findings show that the average productivity of total factors during the period was 1.11 and represented 11% reduction. The average of performance changes was 1.04 and showed 4% reduction. The average of technology changes was 1.12 and represented 12% reduction. The average of qualitative changes was 0.95 and showed 5% improvement in change's trend.
KEYWORDS: productivity, hospital, Malmquistindex, data envelopment analysis

1. INTRODUCTION

Human needs are limitless; however, sources that meet those are scarce. Scarce sources compel people to make the best of current sources and find new ones actualizing the economic growth. Providing the productivity growth represents a country's most appropriately using of its own resources. With the most appropriate use of sources, increase in productivity will be provided. This increase that occurs in productivity brings about the economic growth as well.

Increasing emphasis is being placed on measures of efficiency in hospitals to compare their relative performance given the need to ensure the best use of scarce resources.Productivity in hospitals, as amajorcenter forhealthservices,hasalways been emphasized.With considering developed countries, we can seedifferent methods are presented. It is worth to evaluate hospitals to identify whether they are standard or not, however, it is accuracy and suitability of method and evaluating criteria that makes the job more worthwhile.

During the recent decade, health care system of most countries has faced with a significant increase in health costs, especially hospitals'. This is due to the hybrid impact of factors related to supply and demand. Besides these factors, studies show that the high costs is partly due to inefficient allocating of resources (Yaisawarng, 2002).

The increasing trend of health services' costs in growing population persuades governments and health service providers to draw more attention to quality and productivity of their resources(Malmquist, 1953; Shimshak et. al, 2009, Syam& Cote, 2010; changet. al,2011). However, effective use of healthcare resources is an important goal to increase attention to these services.

The optimum use of limited resources is a major concern in health care management. Lack of health resources, particularly in developing countries is one of the main obstacles in economic development competition and welfare (Aktas et al, 2007). The main goal of improving health services should be to maximize the customer's tranquility conforming to quality health services (Bull, 1994). However, quality is a complex term withthefinancial and resources constraints, increase in patients' demand, firm'scost efficiency consideration regarding qualitativeapproaches (Kanji &sa, 2003).

Hospitals in Iran also consume the more volume of GPD and health budget (Watcharasriroj& Tang, 2004) and the need to ensure the optimum use of limited resources and improve efficiency in health services requires some steps (allocated to this part of health care system) to prevent or reduce wasting resources in order to provide more services, develop access to hospital services and improve their quality. One of the steps is to compare outputs and inputs in order to estimate the efficiency and productivity of a hospital (Jacobs, 2001).

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This study will develop a tool to measure hospitalefficiency by using data envelopment analysis (DEA) and Malmquistproductivitychangeindex[1].DEA is a nonparametric method based on linear programming technique to evaluate the efficiencies of the analyzed units. DEA can measure multiple inputs and outputs, as well as evaluate the measures quantitatively and qualitatively, hence enabling managers to make reasonable judgment on the efficiency of the analyzed units. In this paper, we propose a DEA model to evaluate the efficiency in different hospitals.Also, Malmquistproductivitychange index is decomposed to qualitative change, efficiencychangeandtechnicalchange (Fare et al, 1995).

Specifically, we investigate technical efficiency, purely technical efficiency, and scale efficiency using data envelopment analysis (DEA). In addition we utilize the Malmquist Index approach to measure the evaluation of productivity and efficiency of TEHRAN's hospitals over 2008 and 2009.

2. LITERATURE REVIEW

Measuringthe productivity has been applied to hospitals managementsince1960. Generally,the bestwayto measurehospitalsproductivity is to measure its outputand input. Outputincludes number of hospitalized cases, the number ofclearedcases, and the rate of re-referrals. Inputsinclude staff working hours, food and medical equipment (MedPAC, 1999).

The World Health Report (WHR) (WHO, 2000a), and the Bulletin of the World Health Organization (WHO, 2000b), were devoted to the development and application of a framework for assessing the performance of health systems. The framework includes measurement of three goals of health systems (health, responsiveness and fairness in financial contribution), and an exposition four functions of health systems (including financing, provision, stewardship and resource generation) (Masiye et. al, 2006).

Margyt tested the impact of financial improvements in Australian hospitals on productivity between the years 1994 to 1998 in a research on financial practices. The result was a considerable positive change in technology from 1996 to 1998. While, there was no expected increase in technology efficiency. Also, Mika analyzing the impact of health care system's financial improvements on the productivity of a hospital in Finland found the productivity changes during the years 1994 to 1998 and suggested the state subsidy as a possible factor for hospitals effort in improving performance.

Cheng et al. represented a productivity improvement using Malmquist index and DEA that was mainly influenced by a quality factor (Chang et al, 2011). The results of Sola and Perio's research (2001)indicate a reduction in technical changes and improvement in both quality and efficiency changes. Perio came to a positive technical change and a productivity improvement in 2006. Liam O'Neill et al. reviewed 79 surveys of the years 1984 to 2004 of 12 countries and found marked differences in specifications of various studies both in a selective DEA model and inputs and outputs grouping.Ankarani et al. offered a model based on DEA in 2009 which includes the relations between decision-making process of hospital's departments and technical efficiency.

In 2010, Ching compared input-oriented CCR and the relative input-oriented DEA model to assess the efficiency of hospitals in a research and the results showed that using this model solves false inefficiency in input-oriented CCR model.

Abi Swanson et al. tested the relations between performance and electronic medical records of hospitals in 2009 and they found there was insufficient proof of the effectiveness of these reports on a hospital performance.

Many studies have used the Malmquist productivity index to measure efficiency and technological change of hospital services. Using an input-based MPI, Sommersgutter-Reichmann (2000), studied changes in productivity in the provision of hospital care in Austria between 1994 and 1998. The author found a considerable positive shift in hospital technology between 1996 and 1998 with no enhancement in technical efficiency due to the introduction of an activity-based hospital financing system.

Burgess and Wilson (1995), examined U.S. hospitals from 1985-1988 and found that changes in technology dominated changes in inefficiency in determining changes in productivity. Ferrier and Valdmanis(2008), studied the efficiency and productivity changes in large urban hospitals in the United States and found that during the 1994-2002 period hospitals made modest gains in their economic performance by both improving their technical efficiency and by adopting more productive technologies.

3. METHODOLOGY

This study was conducted in 2011. The study population included two educational and medicinal hospitals in Tehran and data were collected from the study population for the years 2008 and 2009. In this study, variable

[1]DEA-MI

numbers of doctors, beds, nurses and paramedical staff were used as inputs and variable number of outpatients, patients having surgery, the mortality of patients and bedridden days were used as outputs (Chang et al, 2011).

Data were collected from annual statistics of health department of educational and medicinal hospitals and a hybrid approach of DEA and Malmquist index was used to measure the productivity changes and both EMS and Excel soft wares were used to calculate the values. Total factor productivity growth due to changes in technology, efficiency and quality were defined over time. Technology changes are expressed by means of efficiency frontier transfer from t=0 period to t+1 period and changes in technical efficiency is displayed through shifting decision-making unit (DMU) closer to or farther from current frontier.

Qualitative changes are indeed the use of Malmquist index with a specific rewrite in which variables in mortality are involvedas a benchmark against which quality change is measured (Fare et al, 1995; Chang et al, 2011). Given the negative nature, this variable is reversely used incalculations to eliminate its negative effect.

In this study the following relationship is used to measure changes in productivity of Malmquist total factors. This index is presented by Fare et al., (1995) and separates productivity change to three components of technical efficiency change, technological change and qualitative change.

Productivity change = technicalefficiencychange × technologicalchange × qualitative change

$$M = QC \times EC \times TC$$

$$QC = \sqrt{\frac{D_i^0(y^0, a^1, x^0) D_i^1(y^1, a^1, x^1)}{D_i^0(y^0, a^0, x^0) D_i^1(y^1, a^0, x^1)}}$$

$$EC = \frac{D_i^0(y^1, x^1)}{D_i^0(y^0, x^0)}$$

$$TC = \sqrt{\frac{D_i^0(y^1, x^1) D_i^0(y^0, x^0)}{D_i^1(y^1, x^1) D_i^1(y^0, x^0)}}$$

M (index of Malmquist efficiency change) measures the growth rate of productivity in the course of study in this equation and QC (index of quality change) measures qualitative changes between two periods and EC (index of efficiency change) shows the change of performance per unit compared to their counterparts in the period and reflects the production frontier and indicates the distance to this frontier and finally TC (index of technology change), reflects technical progress through estimating the production frontier shift (Fare et al,1995, p.137).

Di is the function of distance and (y^1, x^1) is output and input of t+1 period and (y^0, x^0) is output and input of t=0 period. Malmquist index in the qualitative change equation is indeed with a special rewrite in which the distance function is used and we can apply time changes to Malmquist index equation using a variable time of mortality. Thus, the set of (y^1, a^0, x^1) is the outputs and inputs of period one counting quality criteria of period zero. And, the set of (y^0, a^1, x^0) is the outputs and inputs of period zero counting quality criteria of period one. It is noticeable that all distance functions which are used in the equations are inverse performance values based on Farrell's theory (Farrell, 1957). Due to input-oriented nature of this study, valuesless than one and values more than one indicatehigher and lower productivity respectively and values equal to one reflect awithout ofproductivitychange (Fare et al,1994) (Hosseinzadeh, 2007).

4. DATA ANALYSIS

In the hospitals case study in 2008, there were 339 ± 115 active beds, 119 ± 24 doctors, 271 ± 43 nurses and 237 ± 40 paramedical doctors on average. And, these averages in 2009 were 248 ± 111 active beds, 124 ± 24 doctors, 281 ± 26 nurses and also 249 ± 46 paramedical staff. Average outputs in 2008 were 294390 ± 42841 outpatients, 8637±2772 patients having surgery, 109211 ± 15824 inpatient days and 222±74 of casualties. Average outputs of hospitals in 2009 were 294390 ± 43205 outpatients, 7821±3079 patients having surgery, 100418 ± 15863 inpatient days and 215±61 casualties. Descriptive statistics for2008 and2009are depictedin Table 1.

Table 1; summery information in 2008 and 2009 for research indicators

	2008			2009		
Indicator	Average	Standard Deviation	Median	Average	Standard Deviation	Median
Doctors (X1)	119	24	117	124	24.3	123
nurses (X2)	271	43.3	273	281	36.1	283
Active beds (X3)	237	40.9	241	249	46.6	245
paramedical staff (X4)	339	115.9	336	348.1	111.2	355
Outpatients (Y1)	294390	42841	295578	288578	43205.6	297198
patients having surgery (Y2)	8637	2772.5	8366	7821	3079.1	8179
Inpatient days (Y3)	109211	15834.5	108670	100418	15863.5	101803
Casualties (α)	222	74.6	211	215	61.6	217

The results of input-oriented model and constant efficiency to DEA-MI scale model are presented in Table 3.

Table 3; input-oriented model and constant efficiency to DEA-MI scale model results

Unit	Quality change	Efficiency change	Technology change	Productivity change
DMU1	0.92	0.95	1.03	0.90
DMU2	1.00	1.09	1.16	1.26
DMU3	0.84	0.93	1.05	0.82
DMU4	1.00	1.05	1.08	1.13
DMU5	1.00	1.00	1.00	1.00
DMU6	0.95	1.08	1.23	1.26
DMU7	0.94	0.98	1.34	1.23
DMU8	0.98	1.17	1.03	1.18
DMU9	0.93	1.11	1.18	1.21
DMU10	1.00	1.00	1.00	1.00
DMU11	0.97	0.95	1.08	0.99
DMU12	0.96	1.04	1.13	1.13
DMU13	0.77	0.98	1.02	0.76
DMU14	0.98	0.98	1.22	1.18
DMU15	0.98	1.00	1.16	1.14
DMU16	0.96	1.06	1.12	1.13
DMU17	1.00	1.00	1.00	1.00
DMU18	0.89	0.99	1.18	1.04
DMU19	1.00	1.16	1.08	1.26
DMU20	0.97	1.00	1.28	1.25
DMU21	1.00	1.14	1.23	1.40
DMU22	1.00	1.11	1.28	1.42
DMU23	0.86	0.92	1.04	0.83
DMU24	0.91	0.89	1.23	1.01
DMU25	1.00	1.27	1.02	1.29
DMU26	1.00	1.00	1.00	1.00
DMU27	0.97	1.14	1.14	1.25
Average	0.95	1.04	1.12	1.11

The results of DEA-MI input-oriented with output to a constant scale model shows that quality change indicator of 6 units (1, 6, 9, 13, 23 and 27 respectively with values 0.92, 0.95, 0.93, 0.86, 0.77, 0.97 and 0.82) have the best improvement in quality changing. Quality changes in units 2, 4, 5, 10, 17, 19, 21, 22, 25 and 26 are 1 and it shows that no change is in quality improvements of these units. It can be considered for efficiency change in input oriented and variablereturnsto scalemodelthat the efficiency change is near to 1 and changes are in low range and it is because of being return to scale of variables and reflect the changes more realistic.As it is considered in table 2 the units 1, 3, 11, 23 and 24 respectively with values 0.95, 0.93, 0.95, 0.92 and 0.89 reflect the best improvements and units 8, 9, 19, 21, 22, 25 and 27 respectively with values 1.17, 1.11, 1.19, 1.14, 1.11, 1.27 and 1.14 reflect the worst declining levelof efficiency. For technology change indicator in variable return to scale model for units 5, 10, 17 and 26 is predicted no technology change (the rate of change is equal to 1), and for other units is more than one that shows negative growth in technology change for units under study. Also Malmquist indicator (M) shows the decrease of productivity change.

According to table 2 for DMUs 1, 3, 13 and 23 the smaller amount of 1 are obtained that show the improvement of productivity in investigating time. Furthermore in unit 11 some improvement is considered. For

units 5, 10, 17 and 27 the resulting value for Malmquist is equal to 1 that it means there is no change in that units' productivity. In other hospitals the values were more than 1 and it means there is decrease in productivity change level.
Table 3 shows the Frequency distributionof unitsin relation with indexes mentioned above.

Table 3; frequently of distribution according to change range (DEA-MI_CRS-Input)

Change range	Quality change	Efficiency change	Technology change	Productivity change
CR> 10% (Increase)	4unit	1 unit	-	3 unit
10%>CR>5%(Increase)	4 unit	2 unit	-	-
5%>CR>1%(Increase)	9 unit	6 unit	-	3 unit
CR=1 (no change)	10unit	6 unit	4unit	-
5%>CR>1% (Decrease)	-	1 unit	5unit	1 unit
10%>CR>5% (Decrease)	-	4 unit	4unit	4 unit
CR> 10% (Decrease)	-	7 unit	14unit	16 unit

According to table 2 we can consider that quality change indicator had increased growth in 2009 than 2008 and as a result it can be said that quality criterion was improved. Also the result about efficiency change indicator express decreasing level of changes and it can be said that efficiency change in investigating time was declining and efficiency was decreased in 2009. According to table's information about technology change, it is considered that technology change had decreasedtrend and so it argues that hospital's efficiency in 2009 had decreased than 2008. Finally according to productivity change indicator information in table 2 it can be concluded that productivity changes trend in investigating time was decreasing and as a result the productivity in 2008 was less than productivity in 2009.

5. Conclusion

Based on the results, we understand that total productivity factors in both educational and medicinal hospitals of Tehran declined during the study period and technology changes is the major effective factor in this decline.By using DEA-MI method not only the productivity analysis would be more tangible, but also it can divide productivity changes into three factors (qualitative changes, efficiency changes, and technology changes) and identify the main factor of possible changes.

This research has used the hybrid method in Chang et al., (2011) and Sola and perio (2001) and perio's researches (2006) to measure productivity and shows some different results. Like other researches, they used an approach based on DEA, but the usage is quite different. For example, different DEA approaches with differentspecifications were compared in O'Neil's research. Two DEA approaches were compared inCheng's research. While, in this research DEA approach is compared with combined DEA-MI approach. And, Mr. Swanson measured the relation between electronic records and performance using DEA, but in this study DEA has been used to calculate Malmquist index.

In general, it is recommended to use other indexes of quality changes such as facilities and operating rooms equipment, rates of available drugs, waiting time for patients receiving services, duration of treatment process (Fare et al, 1995), variables and financial ratios like costs per patient discharge, fixed investments and income comparison, and patient discharge and staff comparison (Clevely&harvvey, 1992) and other variables related to hospitals for a better measurement. Regarding the impact of technology as the main factor of reduction in productivity, it is suggested that managers with relevant education be hired in hospitals. And, there could be courses for people in charge on how to use new technologies to keep up with growing technology.

REFERENCES

Abby Swanson, Kazley&Yasar A. Ozcan, (2009) "Electronic medical record use and efficiency: A DEA and windows analysis of hospitals", *Socio-Economic Planning Sciences*, No. 43, p: 209–216.

Aktas, E. Ulengin, F. &Sahin, SO., (2007)."A decision support system to improve the efficiency of resource allocation in healthcare management", *Socio-Economic Planning Sciences*, No.4 , pp.130–46.

Alam Tabriz A., Imani pour M., (2008) "Measuring Relative Efficiency of Health Care Hospitals Using Data Envelopment Analysis(DEA)", *International Journal Of Management Perspective*, No.31, p:139-157.

Ancarani& et al, (2009) "The impact of managerial and organizational aspects on hospital wards' efficiency: Evidence from a case study", *European Journal of Operational Research*, No.194, pp. 280–293.

Burgess, James F. and Wilson, Paul W. (1995). Decomposing Hospital Productivity Changes, 1985-1988: A Nonparametric Malmquist Approach, *The Journal of ProductivityAnalysis*, 6, 343-363.

Chang, S.J., Hsiao, H.C., Huang, L.I. & Chang, H., (2011) "Taiwan quality indicator project and hospital productivity growth", *omega*, No. 39, pp.14-22.

Ching, K.W., Chen, L.C., Li, R.K. & Tsai, C.H., (2010) "Using the DEA-R model in the hospital industry to study the pseudo-inefficiency problem", *Expert Systems with Applications*, doi:10.1016.08.003

Cleverley, W.O. & Harvey, R.K., (1992) "Is there a link between hospital profit and quality?" *Healthcare Financial Management*, 1992, No.9, pp.40–5.

Emamimeibodi A., (2004).Efficiency and Productivity Measurement (In Theory and Practice), Second edition,*Commercial Studies and Research Institute*,Tehran, 2004, p: 115, 19.

Fare, R., Grosskopf, S. & Roos, P., (1995) "Productivity and quality changes in Swedish pharmacie", *International Journal of Production Economics*, No.39, pp.137–47.

Ferrier Garry D. and Vivian G. Valdmanis, (2008). Efficiency and Productivity Changes in Large Urban Hospitals 1994-2002: Ownership, Markets, and the Uninsured, In: Advanced in Health Economics and Health Services Research, Vol. 18: Evaluating Hospital Policy and Performance: Contributions from Hospital Policy and Productivity Research edited by Blank, Jos L. T. and Valdmanis, Vivian G.

Jacobs, R., (2001) "Alternative Methods to Examine Hospital Efficiency:Data Envelopments Analysis and Stochastic FrontierAnalysis", *Health Care Management*, NO.4, pp.103-115.

Masiye, F; Kirigia, J. M.; Emrouznejad, A; Sambo, L. G.; Mounkaila, A; Chimfwembe, D; Okello, D. (2006), Efficient Management of Health Centres Human Resources in Zambia, J Med Syst, 30:473–481

MohamadiArdakani M A., Mir Ghafouri H., Mir Fakhrodini H., Damaki A M., Momeni H., "Evaluating the Relative Efficiency of Public Hospitals in Yazd, using Data Envelopment Analysis Model", Journal of ShaeedSdoughi University of Medical Sciences Yazd, 2008, No.17, p: 67-75

Momeni m., New Topics in Operations Research, Second edition,Tehran University Press, Tehran, 2008, p: 11.

Murray, C. J. L. and Frenk, J. (2000).A framework for assessing the performance of health systems.*Bull. WHO.*78(6):717–731.

Najafi B., BeheshtiDehkordi A., EmamiMeibodi A., (2011) "The productivity of general hospitals of Ardebil Province (1999-2006)", *JQUMS*, Vol.14, No.4, Winter, pp.64-70.

O'Neill, Liam, Rauner, Marion, Heidenberger, Kurt &Krausc, Markus, (2008) "A cross-national comparison and taxonomy of DEA-based hospital efficiency studies", *Socio-Economic Planning Sciences*, No.42, pp.158–189.

Prior D. (2006) "Efficiency and total quality management in health care organizations: a dynamic frontier approach", *Annals of Operations Research*, No. 145, pp.281–99.

Sajedi H., Karami M., Karimi L., Bidram R., (2008) "Efficiency of, Health Care Centers and Public Hospitals of Isfahan University of Medical Sciences in 2004-2005 using Data Envelopment Analysis", *Journal of Health Administration*, No.12(36), p:39-46.

Sola M., Prior D., (2001) "Measuring productivity and quality changes using data envelopment analysis: an application to Catalan hospital", *Financial Account- ability and Management*, No.17, pp.219–45.

Sommersgutter-Reichmann, Margit (2000). The Impact of the Austrian hospital financingreform on hospital productivity: empirical evidence on efficiency and technology changes using a non-parametric input-based Malmquist approach. *Health Care Management Science*(3), 309-321.

Watcharasriroj, B. & Tang, T.J., (2004) "The effects of size and information technology on hospital efficiency", *Journal of High Technology Management Research*, No.15, pp.1–16.

Yaisawarng, S., (2002), Performance Measurement and ResourceAllocation. Boston: Kluwer Academy Publishers.