PRODUCTIVITY OF UNIVERSITY HOSPITALS IN POLAND: A MALMQUIST-INDEX APPROACH

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Abstract. *The purpose of this article is to present the result of productivity analysis of university hospitals in Poland. The hospital sector, and especially the tertiary hospital subsector, are a large consumer of scarce health care resources, and it is of particular relevance to use these scarce resources as effectively and efficiently as possible. This is why it is so important to measure the efficiency and productivity of a hospital to find out whether it is still possible to improve their performance. In this paper, an analysis of 40 tertiary hospitals (which are called university hospitals in Poland) for the period from 2000 to 2007 is presented. To measure hospital productivity, the Malmquist index was employed. The usage of the Malmquist index is based on the data envelopment analysis (DEA), a non-parametric method to estimate the frontier functions, and this is a reason why this method was also employed in this research. The data comprise the number of physicians and nurses employed in university hospitals, the number of beds and the total number of bed days. The results show that in general there has been a worsening of the productivity of these hospitals over this period, and it was caused by an inappropriate usage of inputs. The paper is organized as follows: a brief description of hospital systems in Poland and the concept of their efficiency and productivity are presented, and then the method and data are discussed. In the fourth section, the results are presented, followed by conclusions.*

Key words: *hospital, productivity, health care, DEA, Malmquist index*

1. Introduction

The health care system reform implemented on 1st January 1999 in Poland meant serious changes in the conditions of hospital activities. Most important was changing the status of public hospitals from a budget entity and institution to an independent public institution of health care. What is very important, a hospital participation in the negotiation and contracting their services with a new third party, called Kasa Chorych, was conditioned by this change. Tertiary hospitals in Poland, which provide the most complex health care as compared with the first and second level hospitals, were subordinated to the Ministry of Health.

In these new circumstances, hospitals started to negotiate and contract most of their services with Kasa Chorych without clearly defined rules of finance economy and generally without any experience in the contracting of services. It can be said that a

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decentralization of the system was introduced. But then, from the beginning of April 2003, the centralization of the public funds for health care occurred; as a result, all Kasas Chorych were closed and the National Health Fund was set up. In the meantime, also the change of the owner took place as from the middle of 2001 the tertiary hospitals belong to the medical schools (universities). Especially in those new circumstances, the need to measure the productivity of hospitals arose.

Measuring efficiency and productivity in the health care sector is complicated by the nature of the production process. In the relevant literature, the concept of economic efficiency is generally assumed to be made up of two components – technical efficiency and allocative efficiency. The concept of technical efficiency is defined as the capacity and willingness of a hospital to produce the maximum possible output from a given bundle of inputs and technology (Kalirajan, Shand, 2002). It means that this concept relates to maximizing the output for a given set of factor inputs, whereas an efficient transformation of inputs into output is characterized by a production function, which shows the maximum output obtainable from various inputs, and a hospital production plan is said to be technically efficient if the employed inputs that produce the maximum output or conversely, the maximum output is produced using the least amount of factor inputs. Thus, technical inefficiency is caused by an excessive input usage (Register, Bruning, 2002). Productivity in this context applies to changes in the efficiency between the two periods. Allocative efficiency is defined as the ability and willingness of an economic unit to equate its specific marginal value product with its marginal cost (Kalirajan, Shand, 2002). It means that the production plan of a hospital is said to be allocatively efficient if the factors are employed in correct proportions with respect to input prices. Thus, allocative inefficiency results from employing inputs in the wrong proportions (Register, Bruning, 2002).

So, it means that technical efficiency refers to failure to operate on the production frontier, and allocative efficiency generally refers to the failure to meet the marginal conditions for profit maximization (Chakraborty, Biswas, Lewis, 2001). Economic efficiency in the local sense occurs when technical and allocative efficiency prevail, and the organization is producing the output which maximizes consumer satisfaction (Register, Bruning, 2002).

Measuring efficiency allows ranking and evaluating the hospitals i.e. it facilitates comparisons across similar hospitals thus permitting the design of the incentive mechanism to reward the best hospital, as well as policies to raise efficiency or bear policy implications for the improvement of efficiencies (Mizala, Romaguera, Farren, 2002). Also, it allows undertaking the future analysis to identify the factors causing such variations. Besides, there is a high probability that, in case of technical inefficiency, it will exert an influence on allocative efficiency and that there will be a cumulative negative effect on economic efficiency (Kalirajan, Shand, 2002).

2. Method

To measure hospitals' productivity, the Malmquist productivity index was used. This index was proposed by Malmquist (Malmquist, 1953) and developed by Caves, Christensen, Diewert (1982). The Malmquist productivity index measures total factor productivity (TFP) change between two data points in terms of ratios of distance functions. The calculation of the Malmquist productivity index is based on the usage of a nonparametric method such as data envelopment analysis [DEA].

DEA is a generalization of the nonparametric method of productivity measurement originally developed by Farrell (1957). According to this approach, the proposed measure of the efficiency of any hospital is obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the conditions that the similar ratios for every hospital be less than or equal to unity, expressed by the following formula (Charnes, Cooper, Rhodes):

$$\text{Max } h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \tag{1}$$

subject to:
$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1; \quad j = 1, ..., \text{n}. \tag{2}$$

$$u_r,\ v_i \ge 0; \quad r = 1, ..., s; \quad i = 1,....., m.$$

where y_{rj} is the number of output r from hospital j;
x_{ij} is the number of input i from hospital j;
u_r , v_i are the weights proposed by the solution of the above formula.

All $y_{rj},\ x_{ij}$ (assuming that all are positive) are the known outputs and inputs of the hospital j-th and u_r , $v_i \ge 0$ are the variable weights to be determined by the solution of this problem – by the data on all of the hospitals used as a reference set.

The efficiency of one member of this reference set of $j = 1,\ldots n$ hospitals is to be rated relative to the others. It is therefore represented in the functional for optimization – as well as in the constraints – and further distinguished by assigning it the subscript 0 in the functional (but preserving its original subscript in the constraints). The indicated maximization then accords this hospital the most favourable weighting that the constraints allow.

The DEA approach constructs the best practice production frontier as a piecewised linear envelopment of the available data on all producers in such a manner that all observed points lie on or below the frontier (Hollingsworth, 2003). The DEA measure of efficiency is based on a virtual efficient unit constructed as a weighted average of real efficient units, which is used as a unit of comparison for another hospital. The virtual producer does not necessarily exist, but is imputed from a linear combination of the inputs and outputs of one or more efficient producers.

In mathematical programming terms, this ratio is the objective function to be maximized, where u and v are output and input weights, respectively. In addition, there is a set of constraints, one for each hospital, which reflect the condition that the ratio of virtual output to virtual input must be less than or equal to one for all observed hospitals. Solving the linear programming problem, the efficient or virtual production and the efficiency index are obtained for each hospital.

If the corresponding virtual hospital does better than the real hospital by producing more output with the same level of inputs or the same output with fewer inputs, then the real hospital is inefficient. The procedure for finding the best virtual producer can be formulated as a programming problem for each hospital (Chun-Chu Liu, Chang Jung, Chia-Yon Chen, 2004).

In this technique, the production efficiency of an economic unit is measured in terms of the amount by which output can be increased to increase efficiency. In this case, the ratio of the optimally weighted output to input for the economic unit gives the required measure of production efficiency (Kalirajan, Shand, 2002). It means that the performance of a hospital is evaluated in terms of its ability to either reduce the input vector or expand the output vector subject to the restrictions imposed by the best-observed practice (Chakraborty, Biswas, Lewis, 2001). In this research, the DEA model with the constant return to scale was used.

A major advantage of DEA is that it places no restriction on the functional form of the production relationship between inputs and outputs. Another advantage is that DEA does not require imposition of any distributional assumption on firm-specific effects. Moreover, DEA can accommodate multiple inputs and multiple outputs simultaneously. One of the principal disadvantages is that DEA can be extremely sensitive to the selection of variables and data errors. Another limitation, which is often mentioned in the literature, is that DEA efficiency measures in small samples are sensitive to the difference between the number of hospitals and the sum of inputs and outputs. Due to this limitation, many hospitals may seem to be efficient, even though they are not (Kalirajan, Shand, 2002). In addition, technical efficiency is measured in relative terms compared to the performance of the best productive unit in a sample, thus requiring the use of population data (Mizala, Romaguera, Farren, 2002).

Regarding to the weight computed in the DEA model, it has both advantages and disadvantages as pointed out by Boussofiane, Dyson, Thanassoulis (1991). The advantage is that the weight generated will be fair and equitable and not affected by subjective factors. The disadvantage is that if the weight is selected intentionally, it may make the hospital relatively efficient and its efficiency does not necessarily come from the inherent efficiency but from the section of weight. However, a couple of studies have been proposed to overcome the problems created by complete flexibility of weights in DEA (Chun-Chu Liu, Chang Jung, Chia-Yon Chen, 2004).

DEA has been increasingly applied in economic studies of productive efficiency in public sector enterprises, particularly in the efficiency evaluation of non-profit organizations or governmental departments. It includes health care where market price for output generally is not available (Sengupta, 1998). The DEA method not only ensures an overall consideration of an organization, but also provides an improvement direction for the decision maker, so it can be considered as a more appropriate calculation method than the traditional method such as the ratio analysis and the regression model analysis (Chun-Chu Liu, Chang Jung, Chia-Yon Chen, 2004).

DEA is the most preferred of many listed methods for calculating the Malmquist productivity index (Zere, 2000). The Malmquist productivity index, developed by Caves, Christensen, Diewert (1982), measures the total factor productivity change between two data points in terms of the ratios of distance functions. Following Fare et al. (1994), the output-oriented Malmquist total factor productivity change between periods t and $t+1$ is defined as

$$M_0^{t,t+1}(y^t, x^t, y^{t+1}, x^{t+1}) = \left[\frac{D_0^t(y^{t+1}, x^{t+1})}{D_0^t(y^t, x^t)} \times \frac{D_0^t(y^{t+1,} x^{t+1})}{D_0^{t+1}(y^{t,} x^t)} \right]^{1/2}, \tag{3}$$

where D_0 is the distance functions,

y is the output,

x is the input,

t is the time period

M_0 is the productivity factor.

It means that

$$MI_o^{t,t+1} = \sqrt{\frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)} \frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^t, y^t\right)}}. \tag{4}$$

The form of the Malmquist index defined above is the square root of the product of two indices which both assess the productivity change by calculating the ratio of distance functions based on the same technology for two input–output bundles of two consecutive periods. In case the bundle of the second period is rated with a lower distance than the bundle of the first period, we have an index below unity, which indicates productivity decline. Consequently, a value greater than unity implies improving productivity. The ratio of the two indices gives a Malmquist index as the average of two indices, based on the technologies of two periods (Pilyavsky, Staat, 2004).

Fare, Grosskopf, Lindgren, Roos (1994) further decomposed the MPI into two parts: one measuring efficiency change and another measuring technological change as follows:

$$M_0^{t,}(y^t, x^t, y^{t+1}, x^{t+1}) = \left[\frac{D^{t+1}(y^{t+1}, x^{t+1})}{D_0^t(y^t x^t)}\right] \times$$

$$\times \left[\frac{D_0^t(y^{t+1}, x^{t+1})}{D_0^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D_0^t(y^t, x^t)}{D_0^{t+1}(y^t, x^t)}\right]^{1/2} . \quad (5)$$

The first term on the right-hand side measures efficiency change and the second measures technical change. This index can be decomposed in an index for efficiency change (Fare, Grosskopf, Lindgren, Roos, 1994):

$$\Delta \text{Efficiency} = \frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)}, \quad (6)$$

which is simply the ratio of the distance for two input–output bundles of two consecutive periods, each evaluated in the technology of the respective period. It is obvious that a value greater than unity implies a rising individual efficiency, the so-called catching-up. An index for technical change is given by Fare et al. (1994):

$$\Delta \text{Technology} = \sqrt{\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)} \frac{D_o^t\left(x^t, y^t\right)}{D_o^{t+1}\left(x^t, y^t\right)}}, \quad (7)$$

with $MI_0^{t,t+1}$ = ΔEfficiency × ΔTechnology. ΔTechnology is again the square root of the product of two indices formed as the ratio of the distance functions. Here, the same input–output bundle is benchmarked against two different technologies. In case the bundle is rated more efficient when benchmarked with a technology from an earlier period rather than with a technology from a later period (i.e. $D_o^t(x^{t+1}, y^{t+1}) > D_o^t(x^{t+1}, y^{t+1})$), we have technological progress. Hence, all values of indices greater than unity imply an improvement.

The technical efficiency and the Malmquist index were calculated by using Limdep 9.0 software.

3. Data

As measuring the ideal output – improved health status – is difficult both conceptually and empirically, medical service was accepted as the effect of hospital activities and expressed by the number of bed days. As the inputs, the number of beds (which is treated as a surrogate of physical capital, which is a standard approach in the world research), the number of doctors and nurses were employed. This range of data was also determined by their availability. This is the reason why only one type of output was included in this research.

This research spans over the years 2000–2007, and this period is determined by the availability of data. In Poland, the availability of full data is very poor. The empirical research includes the group of 40 tertiary hospitals – university hospitals located in Poland. There is a total of 43 university hospitals, but three of them were not included in the research as they provide dentist health care and are hardly comparatable with the health care provided by other general and specialized health care hospitals. Data were collected from the Centrum Systemów Informacyjnych Ochrony Zdrowia and aggregated into 11 groups as the Polish Law applying to public statistic forbids providing unit data.

The descriptive statistics on 40 university hospitals located in Poland is presented in Table 1.

TABLE 1. **Descriptive statistics for 2000–2007**

Year	2000	2001	2002	2003	2004	2005	2006	2007
Physicians								
Average	551	563	653	551	676	693	704	653
Median	497	463	722	568	578	632	663	685
Standard Deviation	256	324	333	314	263	269	285	254
Minimum	216	132	198	81	298	341	351	250
Maximum	1 109	1 150	1 154	1 129	1 158	1 242	1 289	1 118
Nurses								
Average	1 129	1 156	1 423	1 035	1 296	1 315	1 338	1 624
Median	988	1 211	1 423	1 125	1 286	1 317	1 317	1 605
Standard Deviation	485	593	503	482	461	461	501	617
Minimum	415	332	682	371	714	654	709	842
Maximum	2 130	2 065	2 087	2 116	2 131	2 221	2 440	3013
Beds								
Average	1 783	1 744	2 068	1 579	1 829	1 801	1 804	1 774
Median	1 738	1 597	2 181	1 503	1 818	1 780	1 702	1 726
Standard Deviation	785	922	755	801	653	612	641	637
Minimum	509	462	1 105	573	1 086	1 055	1 005	1 069
Maximum	3 256	3 272	3 239	3 256	3 200	2 983	3 124	3 116

TABLE 1 (continued)

Patients								
Average	60 736	62 817	78 224	58 929	72 978	75 089	80 217	80 262
Median	53 024	62 696	69 140	54 232	64 180	65 647	70 634	80 364
Standard Deviation	30 893	32 914	32 498	28 707	26 571	28 037	33 408	27 923
Minimum	18 551	15 598	41 534	27 984	41 948	41 857	38 956	46 435
Maximum	116 076	115 807	157 564	132 030	131 130	134 668	152 527	139 536
Bed days								
Average	523 855	518 725	601 894	445 918	495 796	483 254	475 119	469 715
Median	485 500	535 750	631 324	426 950	448 507	432 694	437 324	446 940
Standard Deviation	238 061	273 523	225 610	241 379	194 775	194 567	189 299	172 959
Minimum	159 935	147 769	304 419	140 258	262 774	256 881	259 037	258 285
Maximum	1 005 602	995 102	969 368	942 697	864 740	868 573	855 707	841 523

Source: author's calculation based on CSIOZ data.

The period 2000–2007 can be characterized by:

- increase of physicians by 18.47%
- increase of nurses by 43.86%
- increase of beds by 0.50%
- increase of patients by 32.15%
- decrease of bed days by 10.33%.

4. Results

First, the analysis of hospital activity ratios was employed, and results are presented in Table 2. The average length of patients' stay (ALOS) allows estimating treatment rapidity. The ALOS shows a decreasing tendency in the years 2000–2007; this means that the hospital treatment was intensified. The ratio of hospital bed capacity, which informs how many patients were using the hospital bed (one after another) shows an increasing tendency. The increase of this indicator is also reflected by such changes as an increase of patients while the number of hospital beds and ALOS were decreasing. Also, the ratio of hospital bed occupancy in percentage [it is a quotient of the ratio of hospital bed occupancy in days (a quotient of hospital days to the number of beds) and the real number of year days] decreased from 80.53% in 2000 to 72.39% in 2007. Considering the fact that this ratio is formulated on average at the level of almost 76% and the fact that it is assumed that this ratio should be at the level of 85%, it can be stated that beds are not fully used. This implies that there are too many beds in the hospitals, and it is reasonable to restructurize the hospitals. This ratio shows that hospitals should reduce the number of beds as there are too many of them at this level of the treated patients, especially that it is difficult for the hospitals to increase the number of treated patients as there are some limitations provided by the contract with the National Health Funds which is the monopolist in purchasing health care services. In the analyzed period, the ratio of hospital bed occupancy in percentage was the highest in 2001 and 2000 when these hospitals belonged to the Health Ministry; later, this ratio has been systematically decreasing.

TABLE 2. **Hospitals' activity ratio in 2000–2007**

Ratio / year	2000	2001	2002	2003	2004	2005	2006	2007	Average
ALOS	8.86	8.29	7.84	7.37	6.78	6.48	6.06	5.91	7.20
Hospital bed capacity ratio	33.94	37.03	38.24	39.08	40.06	41.90	44.32	46.06	40.08
Hospital bed occupancy ratio in percentage	80.53	81.85	79.62	76.38	73.13	72.29	71.29	72.39	75.94

Source: author's calculation.

By the DEA method, the technical efficiency of individual groups of hospitals was determined (Table 3).

TABLE 3. **Technical efficiency of university hospitals in 2000–2007**

Group of hospitals / year	2000	2001	2002	2003	2004	2005	2006	2007	Average
1	0.8601	0.9710	1.0000	0.8913	1.0000	1.0000	1.0000	1.0000	0.9653
2	0.9315	0.8285	0.8151	0.7601	0.9266	0.9077	0.8582	0.9471	0.8719
3	1.0000	0.9228	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9903
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9403	0.9925
5	0.9878	1.0000	0.9048	0.9429	1.0000	1.0000	0.9711	1.0000	0.9758
6	0.9793	0.9211	0.8736	0.9519	1.0000	1.0000	1.0000	0.9780	0.9630
7	1.0000	1.0000	0.9424	1.0000	1.0000	1.0000	1.0000	1.0000	0.9928
8	1.0000	0.9284	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9910
9	0.9806	0.9705	1.0000	1.0000	0.8717	0.8621	0.8584	0.9609	0.9380
10	1.0000	0.9617	1.0000	0.9443	0.9001	0.8809	0.8575	1.0000	0.9430
11	0.9949	0.9169	0.9450	0.8926	0.9577	0.9371	0.9223	0.9224	0.9361
Average	**0.9758**	**0.9474**	**0.9528**	**0.9439**	**0.9687**	**0.9625**	**0.9516**	**0.9771**	**0.9600**

Source: author's calcucation.

The results show that many university hospitals could perform better as they could use their inputs in a more efficient way. The average hospital is approximately 96.00% as technically efficient as the best-practice hospitals in the data set. Hospitals are characterized as inefficient in the sense that more bed days could have been performed given the employed resources.

It is very important to underline that the obtained results only suggest relative differences in the efficiency of the analyzed hospitals. Of course, the rating of 1 does not necessarily mean that a hospital is operating in the best possible way. It means that no linear combination of the other hospitals in the study results in a composite unit that produces at least as much output using the same or less input. This is why, based on the generated results, it is impossible to conclude that most hospitals that achieve efficiency at the level of 1 are effective all the time. We may conclude that these hospitals do not differ significantly as their efficiency does not change through the analyzed period. This means that the problem of hospital structure can still exist, which results from the external conditions of hospital activities and which – by using this method – will not appear. If all hospitals function in such conditions, all of them can achieve a higher value of efficiency.

A significant improvement of hospital efficiency was revealed for the years 2000, 2004 and 2007. The average efficiency radically dropped down in 2001. Based on these results, we may conclude that the far-reaching reform process in 1999 had an impact on the change of productivity in 2000 (an improvement was noted); later, the implementation of the National Health Funds did not allow achieving such a high improvement in the productivity as in the previous years of reforming the health care system.

The calculation of technical efficiency allows calculating the Malmquist index. The productivity change over time can be traced for separate hospitals as well as for the entire sample, their Malmquist index being listed in Table 4. The highest productivity changes took place over the period 2001–2000 as a 0.04% increase of productivity can be noted in 2001 as compared to the previous year. In the next years, the productivity varied below 1, which means a decrease. The most significant decrease (5.2%) took place in 2003, i.e. in the year when the National Health Funds were introduced.

TABLE 4. **The Malmquist index of university hospitals for 2000–2007**

Group of hospitals / year	2001/ 2000	2002/ 2001	2003/ 2002	2004/ 2003	2005/ 2004	2006/ 2005	2007/ 2006	Average
1	0.9513	1.0258	0.9441	0.9441	1.0000	1.0000	1.0000	0.9807
2	0.9145	0.8555	0.7871	0.8392	0.9171	0.8826	0.9016	0.8710
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0410	1.0410	1.0000	1.0000	1.0000	1.0000	0.9697	1.0073
5	1.0346	0.9902	0.9237	0.9710	1.0000	0.9854	0.9854	0.9843
6	0.9887	0.9338	0.9119	0.9757	1.0000	1.0000	0.9889	0.9712
7	1.0410	1.0106	0.9708	1.0000	1.0000	1.0000	1.0000	1.0032
8	1.0030	1.0030	1.0000	1.0000	1.0000	1.0000	1.0000	1.0008
9	1.0156	1.0255	1.0000	0.9337	0.8669	0.8603	0.9082	0.9443
10	1.0209	1.0209	0.9717	0.9219	0.8904	0.8691	0.9260	0.9458
11	0.9942	0.9690	0.9184	0.9246	0.9474	0.9297	0.9223	0.9436
Average	**1.0004**	**0.9887**	**0.9480**	**0.9555**	**0.9656**	**0.9570**	**0.9798**	**0.9707**

Source: author's calculation.

The Malmquist index was decomposed to find out the effect of technological change (movement of production function) on the productivity. The results are presented in Table 5.

TABLE 5. **Technological change of the university hospitals in the period 2000–2007**

Group of hospi-tals / year	2001/ 2000	2002/ 2001	2003/ 2002	2004/ 2003	2005/ 2004	2006/ 2005	2007/ 2006	Average
1	0.9797	0.9466	1.0593	0.9441	1.0000	1.0000	1.0000	0.9899
2	1.1038	0.9685	1.0355	0.9057	1.0104	1.0284	0.9519	1..006
3	1.0837	0.9228	1.0000	1.0000	1.0000	1.0000	1.0000	1,0009
4	1.0410	0.9606	1.0000	1.0000	1.0000	1.0000	1.0313	1.0047
5	1.0346	1.0099	0.9796	0.9710	1.0000	1.0148	0.9854	0.9993
6	1.0734	0.9864	0.9580	0.9757	1.0000	1.0000	1.0112	1.0006
7	1.0410	0.9895	0.9708	1.0000	1.0000	1.0000	1.0000	1.0001
8	1.0804	0.9256	1.0000	1.0000	1.0000	1.0000	1.0000	1.0008
9	1.0464	0.9464	1.0000	1.0710	1.0056	1.0022	0.9452	1.0024
10	1.0615	0.9420	1.0291	1.0243	1.0108	1.0136	0.9260	1.0010
11	1.0844	0.9462	1.0289	0.9654	1.0109	1.0080	0.9999	1.0062
Average	**1.0573**	**0.9586**	**1.0056**	**0.9870**	**1.0034**	**1.0061**	**0.9927**	**1.0015**

Source: author's calculation.

These results show that the technological change in general (except in 2004 and 2007) increased the productivity. However, the productivity was decreasing every year compared to the previous (except 2001), which means that the real efficiency levelled the positive effect of technological change significantly. Real efficiency means that inputs were not used in a proper way and there was some wasting of them.

Conclusions

The productivity of 40 university hospitals in Poland was analyzed for the period 2000 –2007. Since health care resources are extremely scarce, it is of interest to see whether any substantial differences in the efficiency of health care providers can be detected. The results shed light on the productivity changes in the university hospitals. They show that their productivity mostly decreased, but at the same time technological changes have occurred in these hospitals. These results also show the urgency of such research.

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