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IMPROVING MANAGERIAL DECISIONS IN THE HEALTH CARE SECTOR. APPLICATION OF PROMETHEE II METHOD TO PUBLIC HOSPITALS

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Problems related to the lack of financial stability of hospitals, which hurt the development of health care, gave rise to the need of implementing appropriate effectiveness measurement methods. Thus, this article aims to assess the functioning of public hospitals in Poland between the years 2007 and 2017. The analysis is based on data reflecting the financial and organisational sphere of individual 321 public hospitals, divided into groups, according to their founding body, at the same time. The PROMETHEE II method in conjunction with the balanced scorecard was implemented. The study allowed one not only to distinguish groups of hospitals with the highest level of effectiveness as compared to the group under study but also to identify the most important criteria that are in shaping it. The application of PROMETHEE II allowed assessing the functioning of hospitals, as well as to compare their results with the results of leaders.

Key words: *performance measurement, health economics, balanced scorecard, decision making, multicriterial methods*

1. Introduction

In recent years, health protection system in Poland has continuously been changing. Unfortunately, it results in financial and economic problems in public hospitals such as indebtedness, lack of liquidity. As health care in Poland is financed on a public basis, this situation appears to be extremely unfavourable not only from the perspective of management but above all, the patients. Financial problems of hospitals manifested in the growing indebtedness are becoming increasingly common.

In Poland, there is a system of compulsory health insurance supplemented by the state budget and local government subsidies. The most important source of funding for universal public health care is the compulsory health contribution paid to the National Health Fund [1]. The second leading source of federal funding is the state budget. The Minister of Health concludes contracts with healthcare providers for the provision of medical

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services. The state budget finances medical emergency services, highly specialised procedures (e.g., transplants, expensive procedures), prevention, administration, and investments.

On the other hand, the budgets of local government units allocate public funds mainly for investments, insurance premiums, and benefits for people that are not covered by health insurance, prevention, health promotion, and public health programs. The financial resources from the state budget and local governments are not a permanent stream of revenues of the health sector, as their level is subject to variable regulations, depending on the decisions of central authorities and local government. What is more, the share of funds from the state budget is not as significant as the costs incurred by the National Health Fund [2].

In the Polish health care system, several types of payment mechanisms coexist, applicable depending on the level of care and type of service provided. In the case of primary health care, the basis of financing is the so-called capitalisation rate (flat rate for the patient) and partly a service fee. Outpatient health care financing is based on a system of homogeneous patient groups and service charges. In the case of hospital care, a system of diagnostic related groups is used. However, the hospital network has introduced a flat rate financing for hospitals qualified for the network [1]. Thus, funding of hospitals in Poland is carried out on public principles from the funds of the National Health Fund. However, there are also other sources of finance for public hospitals in Poland. Some highly specialised services are financed directly from the budget of the Ministry of Health.

Problems related to the lack of financial stability of hospitals, which harm the development of health care, give rise to the need for implementing proper effectiveness measurement methods in the health care sector. Thus, the aim of this article is the assessment of the performance of public hospitals in Poland between the years 2007–2017. The analysis is based on the data reflecting the financial and organisational sphere of 321 public hospitals, divided into groups, according to their founding body.

The paper consists of five parts. Section 2 describes the main issues raised in the literature on the assessment of Polish public hospitals. This section indicates the contribution of the article to the literature on the subject. Section 3 presents a databank used in the study and describes the method applied in the paper – the Preference Ranking Organization Method for Enrichment Evaluation II (PROMETHEE II). Section 4 discusses the results of hospital operation rankings in detail. The final section provides general conclusions and indicates further directions for research.

2. Background

Research on the concept and methods of measuring the effectiveness of enterprises has been experiencing dynamic development in recent decades. Measurement of effec-

tiveness is essential from the perspective of development and competitiveness of enterprises because it enables, through comparative analysis, the assessment of its achievements against the background of other entities. Commonly used methods of measuring effectiveness can be divided into three separate groups: indicator, parametric, and non-parametric. The growing interest in the subject of the effectiveness of public sector entities dates back to the 1970s. Health care effectiveness research was conducted both domestically and internationally [3–14]. There are various approaches to measure the effectiveness of hospitals in the literature. However, there is a consensus that economic analysis, which is the basis for analysis and inference about effectiveness, is not a complete approach to measuring and assessing it.

Initially, the analysis and assessment of the effectiveness of the organisation were considered only from the perspective of financial measures. However, as the years went by, the researchers postulated that the improvement of the organisation's effectiveness could only be obtained based on some conclusions drawn from the analysis of all areas of its activity, without limiting itself only to financial indicators. Many different typologies of measures complement economic analysis (e.g., structural, process, and result measures presented by the Ministry of Health or the breakdown of rules, among others, into statistical, patient satisfaction, or human capital). According to the literature review, correct assessment of the effectiveness of public hospital management should require a combination of two approaches: economic effectiveness and stakeholder satisfaction, which seems to be the most correct. Thus, the measurement of effectiveness is treated as a resultant of "social" and economic effectiveness. Thanks to this dual approach it is possible to make a multi-parametric assessment of effectiveness. In the field of health economics, social, clinical, economic, technical, and cost-effectiveness stand out.

One of the most common methods aimed at improving the management of health care units is the balanced scorecard method proposed in 1992 by Kaplan and Norton [15–17]. Baker and Pink first raised the issue of using the Balanced Scorecard in health care in 1995 and thus caused a significant response among scientists [18–21]. Research on supporting the management of health care units based on the combination of the Balanced Scorecard with selected methods of discrete multi-criteria programming has been conducted to a limited extent in Poland and Greece [22–25].

A study adopting such a comprehensive approach has never been conducted before. That is why this study should be relevant because it makes it possible to use the applied method to evaluate the performance of public hospitals and with the simultaneous separation of "reference" units. What is more, the analysis in time perspective allows one to capture some dependencies that are hardly noticeable in the statical analysis. Moreover, the application of the PROMETHEE II method, in conjunction with the balanced scorecard methodology, seems to be an innovative and not uncommon approach.

3. Methodology and data

3.1. The application of PROMETHEE II

The concept of the PROMETHEE method was developed by Brans and Vincke in 1985 [26]. Currently, there are several extensions: PROMETHEE I, II, III, IV, V, VI, TRI, Cluster, Fuzzy [27]. PROMETHEE II is based on a pair-wise comparison of alternatives for each criterion [27], and the alternatives are evaluated according to different criteria, which have to be maximised or minimised [28]. What is more, each criterion should be able to distinguish the alternatives, regardless of how the alternatives behave under other criteria [29]. The procedure in this method, which leads to the determination of a multi-criteria ranking, can be divided into the following stages.

Step 1. Determination of the value of the preference function for all object pairs in each of the criteria:

$$r^{(\cdot)}(i,\ j)=\begin{cases}0 & \text{if } m_i^{(\cdot)}-m_j^{(\cdot)}<0\\ m_i^{(\cdot)}-m_j^{(\cdot)} & \text{if } m_i^{(\cdot)}-m_j^{(\cdot)}\geq 0\end{cases} \tag{1}$$

Step 2. Determination of the individual $H^{(\cdot)}(i, j)$ preferences for all object pairs in each of the criteria (normalisation of the value of the preference function), which requires the use of so-called generalised preference functions. There are six distinct types of generalised preference functions that range from 0 to 1 [30]. It is possible to choose a different function for each criterion [31].

Step 3. Determination of multi-criteria preference indexes for all object pairs (i, j)

$$\prod(i,\ j)=\frac{\sum_{k=1}^{K} w_k H^k(i,\ j)}{\sum_{k=1}^{K} w_k} \tag{2}$$

where, w_k is the weight of relative importance of the kth criterion.

Step 4. Each alternative can be related to $(n-1)$ alternatives resulting in a positive or negative outranking flow [27]:

$$\Phi^{+}(i)=\frac{1}{m-1}\sum_{j=1}^{n}\pi(i,\ j),\quad i\neq j \tag{3}$$

$$\Phi^{-}(i)=\frac{1}{m-1}\sum_{j=1}^{n}\pi(j,\ i),\quad i\neq j \tag{4}$$

where m is the number of alternatives. The entering flow is a measure of the weakness of the alternatives while leaving one is a measure of the strength of the alternatives [27].

Step 5. Determination of the dominance flows (outputs $\Phi^{+}(i)$, inputs $\Phi^{-}(i)$, and net $\Phi(i)$) for each of the objects using the following formula. Thus, a positive net flow value means that the object i is in the group of dominant objects, while a negative one means that in the group of dominated objects:

$$\Phi(i)=\Phi^{+}(i)-\Phi^{-}(i) \tag{5}$$

Step 6. Determine the ranking of objects based on net dominance flows. The highest $\Phi(i)$ is the best alternative.

3.2. Sample and evaluation criteria

The study was conducted between the years 2007 and 2017 on the data reflecting the financial and organisational sphere of individual 321 public hospitals, divided into groups, according to their founding body. The data was collected from the EMIS (Emerging Markets Information System) and AMADEUS (database of comparable financial information for public and private companies across Europe), and hospitals' financial reports. The study covered hospitals from all over Poland, whose founding bodies were district-commune offices, marshal offices, ministries, and medical universities. Therefore, the sample was constructed which supports the structure of the founding bodies in the population. Such a division resulted from the diversity of sources of funding for hospitals within individual funding bodies. This sample, in its structure, was characterised by representativeness according to the analysed population (Fig. 1).

Detailed test results for sample representativeness are shown in Table 1. This procedure was necessary to generalise the results for the entire population. The χ^2 test was conducted to compare two distributions. Test χ^2 belongs to a group of nonparametric tests, whose algorithm is based on a comparison of the frequency of events resulting from the experiment with the predicted ones. The condition for using the test is a large data population that is met with this test. The χ^2 test was introduced, according to the following notation:

$$\chi^2 = \sum_{j=1}^{k} \frac{\left(O_j - E_j\right)^2}{E_j} \tag{6}$$

where O_j is the observed value of two nominal variables, E_j – expected value of two nominal variables. The tested hypotheses were as follows: H_0: distribution of hospitals according to the funding body in the sample is consistent with the distribution for the entire population (H_1: ~H_0).

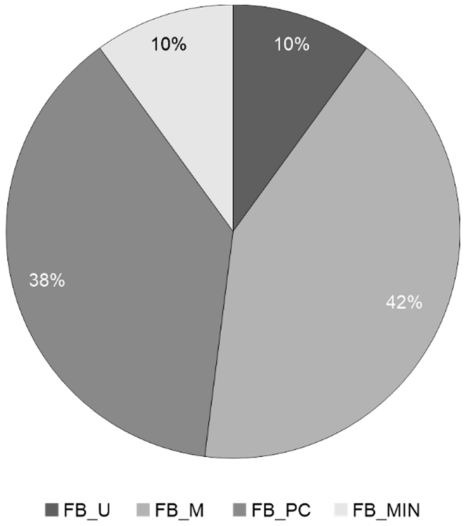

Fig. 1. Sample structure: FB_PC – district commune offices, FB_M – marshal offices, FB_MIN – ministries, FB_U – medical universities

Table 1. Verification of χ^2 test (χ^2 = 7.815)

Value	FB_U	FB_M	FB_MIN	FB_PC	Sum
Observed, O_j	10.0	41.7	10.0	38.3	100
Expected, E_j	7.0	36.0	8.0	49.0	100
$\frac{\left(O_j - E_j\right)^2}{E_j}$	1.3	0.9	0.5	2.3	4.99

As based on the test, there were no grounds for rejecting the null hypothesis. Thus, it can be assumed that the distribution of hospitals according to their founding body in the sample was consistent with the distribution of the entire population. According to the test, the results of the analysis conducted in this study can be generalised to the entire population.

The main purpose of the study was to assess hospitals' operations effectiveness understood by experts participating in the study as the best activity in terms of finance,

patients, and the market, internal processes, development, and stakeholders. It has been defined in the context of rational and effective performance of the unit, whose goal should be the optimal use of its resources. In other words, the facility is characterised by higher operational effectiveness when it achieves better results in individual perspectives (better values of selected indicators within the considered perspectives). However, taking into account the nature of the analysed entities, which in this case are hospitals, within the concept of performance effectiveness, the main emphasis is put on the most effective performance associated with the treatment which, by definition, should be effective and fast. It should be clearly stated that in this situation that the hospital stable financial position is a prerequisite for achieving the goal. Measurement of effectiveness can be conducted through numerous indicators and research methods [25, 32]. Therefore, their precise selection seems to be a key issue. To achieve that the methodology of measures is applied, the Balanced Scorecard method was used [25, 32].

Table 2. Results of the study: evaluation criteria associated with the perspectives of the Balanced Scorecard

Perspective	Evaluation criteria	Weight
Financial	Net_PR	0.0835
	QR	0.0953
	APR	0.0921
	SLV	0.1006
	CpEmp	0.0867
Patient and market	CAP	0.0878
Development	Emp	0.0985
Internal processes	ACC	0.0835
	ALOS	0.0899
	ST_TR	0.0771
Stakeholders[a]	DT	0.1049

[a]The debt ratio can be classified from a financial and stakeholder perspective. However, for the conducted study, it was classified to a stakeholder perspective.

Based on [32].

The analysis was conducted based on several factors affecting the effectiveness of hospital operations. Firstly, the selection of the factors was based on the literature review and indirect interviews conducted with experts in the area of health economics both from the selected hospitals and local universities. Thus, the following measurable reasons for the financial situation of hospitals were selected: the fact of having an accreditation certificate in a given year, quick liquidity ratios, net and operational profitability ratios, average assets productivity ratios, inventory ratio, employment and salary per employee, the average length of stay, capacity indicator, debt ratio, and solvency ratio. Table A1 in the Appendix presents a detailed description of individual factors.

Secondly, the extracted factors were assigned to 5 perspectives used in the Balanced Scorecard Method (Table 2). Then, the experts were obliged to rank the selected indicators on the grounds of the degree of their importance examined in the context of effectiveness of performance of public hospitals in Poland. As based on the obtained results, weights for individual indicators were estimated (Table 2). All the presented indicators will be considered as evaluation criteria in the PROMETHEE II method.

To conduct the PROMETHEE II procedure, the variables were required to be assigned to stimulant and destimulant groups. Thus, the nominative variables were treated as stimulants. The DT variable with the optimal range of values (1.2–1.7) was transformed into a stimulant by assigning its point values based on the guidelines of the Polish Ministry of Health (Appendix, Table A2). This procedure allowed the preparation of data enabling the assessment of hospital performance by the PROMETHEE II method. Moreover, the criteria selected for the analysis were matched with the generalised criteria. Thus, the usual criterion was assigned to ACC, and Gaussian criteria were assigned to others [26].

The following section will elucidate how PROMETHEE II along with Balanced Scorecard can be applied to evaluate and, thus, to improve the effectiveness of the functioning of the health care sector in Poland.

4. Results and discussion

Public hospitals, being units of the public finance sector, are obliged to manage funds to achieve the best possible results at specific outlays. Therefore, the decisive factor, in this case, is the justifiable incurring costs directly related to the actions taken to obtain the intended effects. The assessment of the performance of public hospitals in Poland using Balanced Scorecard was dictated by an in-depth analysis of the literature on the subject and as a consequence of previous research [25, 32]. It showed that this method, in a coherent way, combines the financial and organisational sphere of the entity, showing comprehensively and holistically the functioning of the entire entity. It enables the performance evaluation based on both financial and non-financial ratios, and seems reasonable to be used for hospitals that are non-profit entities, but regardless of those having the potential to make a profit that should always be allocated to development determined by increasingly stronger competition on the market [25]. Thus, in the study, a research hypothesis was formulated that the growing indebtedness of hospitals harms the effectiveness of their functioning. Before the PROMETHEE II procedure was incorporated, all the analysed units had been assigned to one out of four groups referring to the founding body. Thus, there were distinguished groups of the university, district-commune, marshal, and ministerial hospitals. The criteria used to assess individual groups were calculated, respectively.

First, according to what performance scores each of the group possesses, an evaluation matrix is formed (Table 3). The criterion weight has not been changed during the analysed years (for the values see Table 2).

Table 3. Evaluation matrix

Subject	ACC	ALOS	APR	CAP	CpEmpl	DT	Emp	Net_PR	QR	SLV	ST_TR
Direction	max	min	max	max	min	min	max	max	max	max	min
Weight	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.08	0.10	0.10	0.08
FB_U	0.34	6.24	0.02	46.21	0.03	0.85	1576.31	0.01	1.21	–0.05	11.17
FB_M	0.44	6.23	–0.01	43.27	0.03	0.74	930.91	–0.02	0.55	–1.43	9.27
FB_PC	0.31	6.10	–0.01	45.25	0.03	0.77	619.70	–0.02	0.57	0.18	5.63
FB_R	0.25	5.50	0.00	48.79	0.04	0.83	1035.44	–0.01	0.62	0.82	8.00

Before acquiring the ranking order of the groups of hospitals according to their performance on each criterion, a specific preference function and thresholds were defined. While setting the preference function, criteria, and data structure are considered, regarding their special features [33]. Preference functions and thresholds for all criteria are calculated. As a result of the procedure carried out under the PROMETHEE II method, positive flow (Φ^+), negative flow (Φ^-), and net flow (Φ) values were obtained (see Table 4). What is more, the more detailed results of the analysis, concerning the sensitivity analysis of weight changes, are presented in Appendix in Table A3. All the calculations are made in MS EXCEL based on VBA macros.

Table 4. PROMETHEE II flows

Alternative	Year					
	2007			2017		
	Φ^+	Φ^-	Φ	Φ^+	Φ^-	Φ
FB_U	1.356	0.633	0.723	1.434	0.626	0.808
FB_M	0.843	0.691	0.152	0.600	1.046	–0.446
FB_PC	0.701	1.102	–0.401	0.610	0.933	–0.323
FB_MIN	0.669	1.143	–0.474	0.891	0.930	–0.039

According to the net flows, the rankings of the functioning of the analysed hospitals were obtained, which were then ordered from the worst to the best units between the years 2007–2017 (Fig. 2).

The results obtained in the study were strictly associated with the values of indicators and their weights. Thus, according to experts, the most important criteria are SLV and DT, thus indicating that despite the nature of hospitals as non-profit units, the financial sphere seems to be strategic. In terms of Balanced Scorecard perspectives, it should be underlined that among the hospitals in question, marshal's hospitals' group had the highest percentage of hospitals with accreditation certificate. Ministerial hospitals were the worst here. The hospital's possession of accreditation certificate is the

result of implementing quality improvement programs, which is a kind of indicator of the hospital's prestige. Accreditation is aimed at confirming that the entity providing health services meets the accreditation standards in the field of delivering health services and functioning of this entity. Hospitals that are also accredited relatively easily obtain ISO certification, but not vice versa, which is associated with the criteria that a given unit must meet. The main difference concerns the scope of the assessment: the entire unit is assessed for accreditation, and one or several departments can be submitted for ISO certificates. In other words, the requirements that an institution has to meet for accreditation are more stringent because they apply to the entire entity.

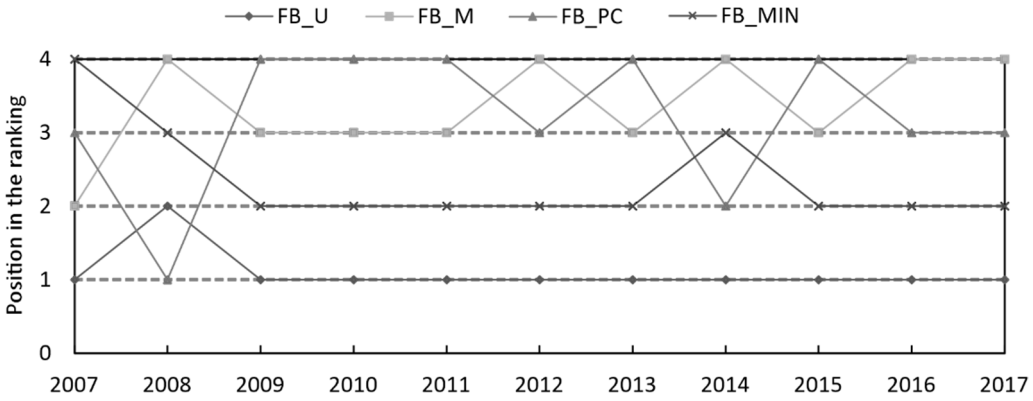

Fig. 2. Rankings between the years 2007–2017

The average length of stay did not differ significantly in all the groups and was about six days. University hospitals had the best values of indicators in the scope of APR. Marshal and district-commune hospitals were definitely the worst.

Debt ratios of the analysed hospitals significantly exceeded the 30% level recommended by the Ministry of Health. A vast majority of hospitals showed values above 100%, which indicated undermining hospitals' credibility. The least indebted hospitals were the marshal hospitals and the most indebted the university hospitals. However, these hospitals had one of the highest employees' costs, as opposed to ministerial hospitals. The stock rotation is also essential for hospital operations, as it shows in what cycle the unit renews its inventory to provide health services. The lower the value of the indicator, the more efficient inventory management. In all the analysed years, hospitals showed the inventory turnover ratios within the range of 15 days. Only university hospitals had safe levels of QR ratio. All other groups were characterised by quick ratio values below 0.62, which indicated a severe threat to paying off current liabilities. Thus, the hospitals with the highest effectiveness of performance within the considered criteria were university hospitals. Apart from 2008, they held the leadership position in all the

analysed years. It was related to proper functioning within the analysed indicators, except for the DT and SLV indicators. However, they showed, unlike other entities, the potential to pay current liabilities and better results under APR and Net_PR. The groups of hospitals performing worse, compared to the group under the study, were the ones of marshal's and district-commune hospitals.

5. Conclusions

In this paper, some light was shed on the question of how to identify the most effective groups of hospitals concerning criteria related to the Balanced Scorecard method. For this purpose, the PROMETHEE II method was applied.

The study allowed not only to distinguish groups of hospitals with the highest level of effectiveness as compared to the group under study but also to identify the criteria that are most important in shaping it.

The application of PROMETHEE II allowed assessing the functioning of hospitals, as well as to compare their results with the results of the leaders. Thus, it creates some opportunities to improve the operation of units further in the ranking by using good practices of the leaders. Hence, the results of the study might be a starting point of more effective allocation of resources. Additionally, embedding the research from the perspective of 11 years provides detailed information for policymakers and hospital managers regarding the dynamics of hospital effectiveness, that is, how the ranking order has changed over time.

The study was associated with certain limitations. The most important of them included limited access to financial and organisational data of hospitals. The incompleteness of data within the time series was another problem. Although the study was carried out on a representative group of hospitals, in the future the author will attempt to increase the scope of the sample. Future studies will consider the relationship between the results obtained in this study and the specific financial situation of hospitals.

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Appendix

Table A1. Selection of variables used in the analysis

Symbol	Description
DT	debt ratio – the degree of financing assets with foreign capital that should not exceed the level of 0.3, for DT = Lpl/(BSh Tot), where Lpl – liabilities and provisions for liabilities for long--term liabilities + short-term liabilities + provisions for liabilities + accruals + special funds; BSh_Tot – balance sheet total.
FB	founding body, where: FB_U – university hospital, FB_M – marshal hospital, FB_PC – district-commune hospital, FB_MIN – resort (ministry) hospital.
ACC	certificates of accreditation – the fact of having the certificate in the analysed year means with 1 for hospitals that have certificates of accreditation.
ALOS	average length of stay (days) – the number of days that a patient stays in the hospital
CAP	capacity indicator – presenting the number of patients using successively 1 bed in the reporting period.
SLV	solvency ratio illustrates how many times the liabilities exceed equity. It is suggested that its value should oscillate between 0.01 and 0.5, for SLV = (LtL + STL + SF + Acr)/*E*, where: LtL – long-term liabilities, STL – short-term liabilities, Acr – accruals and prepaid expenses, SF – special funds, *E* – equity.
QR	quick ratio shows the hospital's ability to pay its liabilities in time, but it is more precise because it excludes inventories from current assets. The recommended value of this indicator should be in the range of 1.0–1.2. QR = ((CA – stock)/STL) × 100%, where: CA – current assets understood as the sum of stock, short-term receivables, short-term investments and cash, STL – short-term liabilities.
Net_PR	net profitability ratio illustrates the share of the net results in total revenues and should reach values above the level of 5%, for Net_PR = (Net profit (loss)/Tot Rev)×100%, where: Tot_Rev – total revenue: net sales revenues + other operating revenues + financial revenues + extraordinary profits + adjustments – write-off of negative goodwill + profit on shares in subsidiaries valued with the equity method + profit on the sale of all shares in subsidiaries.
APR	asset productivity ratio showing the entity's operating result in total assets. The desired values of this indicator should be in the range of 3–6%. APR = (operating result/total assets) ×100%.
STTR	stock turnover shows in what cycle the unit renews its reserves to provide health services. Its optimal value should be lower than 15 days . STTR = (Stock/Sales revenues) × 365.
Emp	employment in thousands of people.
CpEmp	cost per employee (PLN).

All the suggested values presented in the table indicator originate from the Polish Ministry of Health, www2.mz.gov.pl/wwwfiles/ma.../docs/anali_wskaznik_24112006.pdf (accessed:15.09.2018).

Table A2. Guidelines for scoring DT

Range of values	DT < 0.6	0.6 < DT < 1.2	1.7 > DT > 1.2	DT > 1.7
Point assessment	0	8	12	10

Criterium	Object losing one position in the ranking	Permissible weight (bottom)	Original weight	Permissible weight (from the top)	Object losing one position in the ranking
ACC	_U	–0.1281	0.0835	0.1143	FB_PC
ALOS	FB_R	0.0066	0.0899	0.3122	FB_U
APR	FB_R	–0.0606	0.0921	3.9152	FB_PC
CAP	_PC	0.0071	0.0878	0.4836	FB_U
CpEmp	FB_U	–0.1067	0.0867	0.1953	FB_R
DT	*****	–10000000150474700000000000000000		0.2140	FB_R
EMP	F _R	–0.0704	0.0985	0.1938	FB_PC
Net_PR	_R	–0.1806	0.0835	0.9370	FB_PC
QR	FB	–0.1372	0.0953	10000000150474700000000000000000.0000	******
SLV	F _PC	0.0624	0.1006	0.7103	FB_U
ST_TR	B_PC	0.0347	0.0771	0.2272	FB_R