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ASSESSMENT OF FUNCTIONAL EFFECTIVENESS OF THE LONG-TERM SOCIAL CARE INSTITUTIONS IN LATVIA'S MUNICIPALITIES BY THE DATA ENVELOPMENT ANALYSIS METHOD

Social protection is one of the most important functions of the state and local governments in relation to their citizens, especially to those who are in difficulty, affected by various diseases and the elderly ones. Municipalities in Latvia function at different economical levels that are determined by geopolitical, socio-economic, demographic, etc. factors that in turn affect the performance of various functions by local governments. One of these functions is the provision of long-term social care services to retired people. In circumstances, when local government finances are limited and the demographic structure is changing, characterized by an aging population, it is important to achieve the most effective use of financial resources in the long-term social care institutions (LSCIs). The functional effectiveness of the LSCIs in the context of the use of financial resources using science-based econometric methods has not been evaluated in Latvia by now, therefore the aim of the study is to determine the most effective LSCI as for criteria taking the indicators of financial and other available resources of the currently functioning local government LSCIs. Within the framework of this study, the authors, using data from the Ministry of Welfare of the Republic of Latvia on the LSCIs of the elderly, are evaluating the functional effectiveness of these institutions using the Data Envelopment Analysis (DEA) method. After analysis of the functional effectiveness of 64 LSCIs by designing four DEA models, the authors identified the most effective LSCI – *Ventspils* Social Care Home *"Selga"* and *Viļaka* Social Care Center. The novelty of the research is the authors' approach to assessing the functional effectiveness of the Latvian LSCIs using the DEA method, that allows to identify the most important parameters for the assessment of LSCIs functional effectiveness to ensure the stability of the social care field in Latvia.

Key words: municipalities, long-term social care institutions (LSCIs) Data Envelopment Analysis (DEA) method, functional effectiveness, Latvia.

Latvijas pašvaldību ilglaicīgās sociālās aprūpes iestāžu funkcionālās efektivitātes novērtēšana ar datu čaulas analīzes metodi

Sociālā aizsardzība ir viena no svarīgākām valsts un pašvaldību funkcijām attiecībā pret saviem pilsoņiem, sevišķi pret grūtībās nonākušām, dažādu slimību skartām un vecumu sasniegušām personām. Latvijas novadu pašvaldības funkcionē dažādos ekonomiski atšķirīgos līmeņos, ko nosaka ģeopolitiski, sociālekonomiski, demogrāfiski u.c. faktori, kas savukārt ietekmē pašvaldību dažāda rakstura funkciju veikšanu. Viena no šādām funkcijām ir ilglaicīgās sociālās aprūpes pakalpojumu nodrošināšana pensijas vecumu sasniegušām personām. Apstākļos, kad pašvaldību finanšu līdzekļi ir ierobežoti, kā arī aizvien pieaugošās demogrāfiskās struktūras izmaiņu dēļ, kam raksturīga ir arī sabiedrības novecošanās, ir svarīgi panākt pēc iespējas efektīvāku finanšu līdzekļu izmantošanu ilglaicīgās sociālās aprūpes iestādēs (ISAI). Latvijā līdz šim nav vērtēta ISAI funkcionālā efektivitāte finanšu līdzekļu izmantošanas kontekstā, izmantojot uz zinātni balstītas ekonometriskās metodes, tādēļ pētījuma mērķis ir noteikt efektīvāko ISAI par kritērijiem ņemot pašreiz funkcionējošo novadu pašvaldību ISAI finansiālo un citu pieejamo resursu rādītājus. Šī pētījuma ietvaros autori, izmantojot Latvijas Republikas Labklājības ministrijas datus par pašvaldību pārziņā esošām vecu ļaužu ISAI, veic šo iestāžu funkcionālās efektivitātes novēr-

tēšanu pielietojot datu čaulas analīzes (DČA) metodi. Analizējot 64 ISAI funkcionālo efektivitāti, veidojot četros DČA modeļus, autori identificēja visefektīvākos ISAI – Ventspils Sociālās aprūpes namu "Selga" un Viļakas sociālās aprūpes centru. Pētījuma novitāte ir autoru pieeja Latvijas ISAI funkcionālāsefektivitātes novērtēšanai, izmantojot DČA metodi, kas ļauj identificēt efektīvākos pakalpojumu sniedzējus pēc noteiktiem saimnieciskās darbības rādītājiem.

Atslēgas vārdi: pašvaldības, ilglaicīgās sociālās aprūpes iestādes (ISAI) datu čaulas analīzes (DČA) metode, funkcionālā efektivitāte, Latvija.

Определение функциональной эффективности учреждений длительного социального ухода самоуправлений Латвии методом анализа свёртки данных

Социальная защита является одной из важнейших функций государства и самоуправлений по отношению к своим гражданам, особенно к тем из них, кто находится в затруднительном положении, кто пострадал от различных заболеваний, и лицам пожилого возраста. Самоуправления в Латвии функционируют на экономически разных уровнях, определяемых геополитическими, социально-экономическими, демографическими и другими факторами, которые, в свою очередь, влияют на выполнение самоуправлениями своих функций. Одной из таких функций является предоставление услуг длительного социального ухода лицам, достигшим пенсионного возраста. В условиях, когда финансы самоуправлений ограничены, а также меняется демографическая структура общества, характеризуемая старением населения, важно добиться наиболее эффективного использования финансовых ресурсов в учреждениях длительного социального ухода (УДСУ). До сих пор функциональная эффективность УДСУ в контексте использования финансовых ресурсов с применением научно-обоснованных эконометрических методов в Латвии не оценивалась, поэтому цель исследования состоит в том, чтобы определить наиболее эффективный УДСУ, используя в качестве критериев показатели финансовых и других доступных ресурсов действующих в настоящее время при самоуправлениях Латвии УДСУ. В рамках данного исследования авторы, используя данные Министерства благосостояния Латвийской Республики об УДСУ, оценивали функциональную эффективность этих учреждений с использованием метода анализа свёртки данных (АСД). Анализируя функциональную эффективность 64 УДСУ при разработке четырех моделей АСД, авторы определили наиболее эффективные УДСУ – Вентспилсский дом социального ухода *"Selga"* и Вилякский центр социального ухода. Новизна исследования заключается в авторском подходе к оценке функциональной эффективности УДСУ в Латвии с использованием метода АСД, позволяющего идентифицировать наиболее эффективные УДСУ по определённым параметрам хозяйственной деятельности.

Ключевые слова: самоуправления, учреждения длительного социального ухода (УДСУ), метод анализа свёртки данных (АСД), функциональная эффективность, Латвия.

Introduction

In recent years, the issue of ageing population and demographic changes has become more and more relevant not only in Latvia, but also in Europe as a whole. According to population forecasts, the European Commission data shows that the number of people over 60 years of age in Europe continues to increase (Slimibu profilakses un kontroles centrs 2012). Also, in Latvia, according to Eurostat, the number of people aged 65 and over continues to increase, while the number of working people is decreasing, and, according to the European central statistical forecasts, this trend will remain in the next decade (see Table 1).

Table 1

Changes in the demographic structure of the working-age and retired population in Latvia

Year	2015	2020	2030 (forecast)
Number of people at working age, 18–64	1 255 627	1 147 041	932 781
Number of people at retirement age, 65 and over	382 566	385 918	414 164
Dynamics of working age people aged 18–64, %	100%	91%	74%
Dynamics of retirement age people aged 65 and over, %	100%	101%	108%

Source: European Commission 2012.

The Constitution of the Republic of Latvia stipulates that everyone has the right to social security in old age, for work disability, for unemployment and in other cases as provided by law (Satversmes Sapulce 1922). One of the direct national regulatory authorities in Latvia, the Ministry of Welfare, is responsible for social security, work and gender equality, while the types of social services, their principles and the procedure for their receipt in Latvia are regulated by the Law on Social Services and Social Assistance (Saeima 2003). This law also determines the division of responsibility between the state and local governments in providing social services to the population.

Social protection is one of the most important functions of the state and local governments in relation to their citizens, especially those facing difficulty, those affected by various diseases and those who have reached a certain age. Social protection includes a social security system aimed at ensuring complete social protection of a person, while the social services system is part of the social security system of Latvia.

Although several non-governmental organisations, foundations and private bodies are involved in the provision of social services, basically, the responsibility for long-term social care institutions (LSCIs) in the regional and economical and political model of Latvia is divided between the state and local governments. Local governments of the regions in Latvia have different funding, which depends on the geographical location and size of the territory, as well as the size of population living in the municipality, the business environment in the region, the budget revenue of local governments and other factors (Saeima 1994). The unequal economic levels of these municipalities are regulated by the procedure for the distribution of municipal finance equalisation funds, which provides that economically secured local governments make larger contributions to the equalisation fund than less economically secured local governments, thus supporting these economically weaker municipalities (Saeima 2018). Regardless of the procedure for the distribution of the municipal finance equalisation funds, which provides that economically secured municipalities that make contributions to the equalisation fund will in any case see financial growth, in contrast to economically weaker municipalities, which will experience greater financial deficits. It should be noted that there are only 15 municipalities that make contributions to the fund, while the other 104 municipalities are dependent on the municipal financial equalisation fund grants (Latvijas pasvaldibu savieniba 2018).

Municipalities in Latvia function at economically different levels determined by the geopolitical, socio-economic, demographic and other factors, which, in turn, affects the performance of different functions of the municipalities. One of such functions is the provision of long-term social care services to individuals who have reached retirement age. Long-term social care institutions and statutory state-established LSCIs are subject to the Ministry of Welfare, while regional care centres are managed by the particular municipality. This division of ownership of long-term care facilities between the state and municipalities creates a certain imbalance in the overall system of social care services, since, without being either subordinated or subject to the Ministry of Welfare, these LSCIs remain attached and dependent on the region in which they are located, as well as the economic situation of the regional municipality, and the Ministry of Welfare is not responsible for the development prospects of these institutions.

By setting a goal to determine the most cost-effective and technically effective municipal LSCIs, the authors are allowing one to identify the most important parameters for assessing the performance of LSCIs, as well as to identify the most efficient service providers and the resulting, most optimal size of an institution, the scope of services provided, the financial flow, etc. To achieve this goal, the authors have analysed the available literature on the topic of the work, performed LSCI and data selection based on certain criteria, performed the evaluation of the effectiveness of LSCIs using the Data Envelopment Analysis (DEA) method and analysed the obtained results. The results of the study are relevant in the current economic situation to help municipalities balance resources for optimising existing LSCIs, as well as creating new institutions.

1. Research methodology, data acquisition and processing

In order to determine the most effective service provider, thus determining the optimal size of the institution, quality of service, financial flow, etc., one must evaluate the existing LSCIs with econometric methods.

One of the tools used to evaluate effectiveness is the DEA method. The theory of microeconomics deals with the concept of effectiveness, or the relationship between the resources invested and the results obtained (Kotane 2014). DEA is considered to be one of the methods that analyses and studies the relationship between inputs and outputs. One of the most important authors in this field is M. Farell, who in his 1957 publication described the need to develop better models for the better evaluation of productivity of organisations (Cooper et al. 2011). The ideas of M. Farell were used as a basis by A. Charnes, W. Cooper and E. Rhodes (Charnes et al. 1978), who first introduced the DEA method. Currently, the DEA method is used both in the public sector to evaluate schools, hospitals, health care systems and universities, as well as the private sector, such as banks and financial institutions (Emrouznejad et al. 2014). The Danish Ministry of Finance has recognised the DEA method as one of the best methods to compare organisations of the public sector (Finansministeriet 2000).

A search for scientific literature on efficiency evaluations in the public sector shows that databases contain publications on the evaluation of hospitals, health care

systems and social care institutions. For example, R. Jacobs, using the DEA and Stochastic Frontier Analysis (SFA) methods, evaluated the cost effectiveness of hospitals (Jacobs 2001). Other authors have also used DEA to evaluate the cost effectiveness of hospitals (Ferrier et al. 2006). Some literature sources indicate that the DEA method has even been used to evaluate health care systems. For example, authors such as F. Elba, C. Ciappei, R. Rialti and L. Zollo have used the DEA method to evaluate the healthcare system in Italy (Elba et al. 2017). Meanwhile, J. Medeiros and C. Schwiers used the DEA and SFA methods to evaluate the European Union's healthcare systems (Medeiros, Schwierz 2015). The European Observatory on Health Systems and Policies has also used the DEA method in the evaluation of healthcare systems (Cylus et al. 2016).

With regard to long-term social care institutions, the DEA method has been used to evaluate the technical effectiveness of these institutions (Kleinsorge, Karney 1992). P. Kooreman has studied Dutch long-term social care institutions, concluding that 50% of these institutions are effective (Kooreman 1994). In 2005, Finland also carried out a study using the DEA method to assess technical effectiveness and compare it with care outcomes in long-term social care. As quality performance indicators, this study used indicators such as the prevalence of trauma in long-term care settings, etc. The resources applied were the number of nurses, the size of the infrastructure, etc. (Laine et al. 2005).

The method was also used to study the effectiveness of non-profit and commercial long-term social care institutions (Rosko et al. 1995). Several studies have been carried out on the forms of property and effectiveness, using the DEA method in long-term social institutions. For example, R. Anderson, S. Weeks, B. Hobbs and J. Webb study notes that US long-term private social care institutions are more effective than non-commercial institutions (Anderson et al. 2003). However, analysing the quality of service within the framework of this study reveals that the quality of service in non-commercial long-term social care institutions is better than in private institutions. Another study on the quality and effectiveness of service in long-term social institutions in the US was carried out. In his study, N. DeLellis points out that the quality of service in long-term social care institutions is linked to effectiveness, i.e. the institutions showing high effectiveness according to DEA had worse quality of care processes (for example, the quality of processes in N. DeLellis' study is understood as the percentage of individuals living in nursing homes that use painkillers and analgesia), while performance indicators for care (such as the percentage of individuals with immobility living in nursing homes) were better (DeLellis 2009). Other authors have also attempted to integrate quality aspects into the DEA method by assessing the quality of long-term social institutions (Shimshak et al. 2009).

In the context of an ageing population, Japan has also made an assessment of the effectiveness of long-term social care institutions by assessing both the costs and expenses, and the effectiveness of the infrastructure by comparing the institutions in different regions of Japan (Yamauchi 2015). Similarly, the European Union has performed a study related to the effectiveness of long-term social institutions using DEA. The European Union's study assessed the technical effectiveness of these institutions (infrastructure and resources) as well as care processes in the palliative phase. Only six European Union countries were included in the study (Wichmann et al. 2018).

Based on the analysis of literature described above, the author chose to use the DEA analysis method to evaluate the effectiveness of LSCIs.

Description of the DEA method. DEA is a mathematical programming method that can be applied to any field of activity and object against which input and output values are evaluated. Determining of effective objects is performed by comparing each of these values with all of the rest. The comparison can be made based on each of the input and output values studied, but these values must be measurable.

The advantage of this method is that any subjective judgements in relation to the weight of the parameters included in the assessment are excluded, because DEA determines the optimal weight of each parameter by linear programming, i.e. each assessed item is assigned a weight at which the desired effectiveness indicator will be maximised. So, in the DEA method, the LPT (Linear Programming Task) system is created and effectiveness coefficients are found by maximising the target function. But, since the weight of each item is optimal, it can be used to assess the strengths and weaknesses of the object. In other words, the higher the weight of the input or output parameters, the better the object parameter is relative to others, and vice versa.

All input and output parameters of DEA are transformed into one specific effectiveness index and the relatively most effective ones are those whose maximum individual weighted input/output parameter ratio is not exceeded by other objects from the analysed set.

The method is flexible enough to allow the user to select the input and output parameters to obtain the integrated effectiveness indicator. However, the inclusion of different parameters in the assessment should be logical, as each of them will have a radical impact on the outcome (Hammershmidt et al. 2018).

Before looking at the definition of the DEA model itself, the relative measure of effectiveness is first defined (Farrell, Fieldhouse 1962).

$$Effectiveness = \frac{weighted\ sum\ of\ output\ variables}{weighted\ sum\ of\ input\ variables}, \quad (1)$$

which can be written down as:

$$EFF_m = \frac{W_1Y_{1m}+W_2Y_{2m}+\cdots+W_sY_{sm}}{V_1X_{1m}+V_2X_{2m}+\cdots+V_rX_{rm}} \quad (2)$$

where

EFF_m = effectiveness factor for institution m
W_j = weight of the output variable j
Y_{jm} = value of the output variable j for institution m
V_i = weight of input variable i
X_{im} = value of input variable i for institution m

The basic DEA LPT system is defined as follows:

Target function:

$$h_0 = \frac{\sum_{j=1}^{s} W_j Y_{j0}}{\sum_{i=1}^{r} V_i X_{i0}} \rightarrow max \quad (3)$$

Conditions (restriction):

$$\frac{\sum_{j=1}^{s} W_j Y_{jm}}{\sum_{i=1}^{r} V_i X_{im}} \leq 1, m = 1,2, \ldots, n \quad (4)$$

$$W_j \geq 0; j = 1,2, \ldots, s$$

$$V_j \geq 0; i = 1,2, \ldots, r$$

where

h_0 = target function optimised
Y_{jm} = value of the output variable j for institution m
W_j = weight of the output variable j
X_{im} = value of input variable i for institution m
V_i = weight of input variable i
n = number of institutions to be assessed
s = number of input variables
r = number of output variables (Charnes et al. 1978).

By solving the DEA linear programming task, we obtain the weights of the output and input variables, based on which the effectiveness ratio of each institution is calculated.

Efficiency, effectiveness and productivity. Efficiency and effectiveness are two very common keywords that are widely used by business, marketing, and management professionals to describe and analyse the development strategy and direction of a company or institution. Although these terms are widely used, they are often misinterpreted (Goh 2013). Efficiency is the ability to do something well and effectively, without wasting time, money or energy (Summers 2006), i.e. how easy, fast, or inexpensive it can be to achieve a goal or obtain maximum return on limited resources, or use these resources with minimal or no loss, by using a particular tool, method or type of action. Efficiency in management is understood as the degree of goal achievement and the implementation of the right goals (Klauss 2000).

Efficacy, on the other hand, is the ability to produce the right or expected result. Effectiveness is a process that results in a planned result and characterises the quality of system processes (Summers 2006).

It is possible that efficiency may harm effectiveness. For example, if a company is new, its performance is often effective but not very efficient. In order to survive, the company is trying to accommodate the market and, as it gradually grows older, its operations become more efficient, however, as the efficiency increases, its performance becomes less effective. It contains many systems, but they change slowly. If there is no change, the company becomes less and less responsive to the changing needs of the market and becomes ineffective. When efficiency increases, profits will also increase, but if profits are only earnt on the basis of efficiency, then their growth will only be possible by reducing costs (Adizes 2018).

Productivity is directly related to the efficiency of products or services. It is the unit cost measure that expresses the amount of goods or services produced, taking into account the work, time and money invested (Summers 2006).

In the case of one input and one output variable, effectiveness is usually measured as follows:

$$Effectiveness = \frac{output\ variable}{input\ variable} \quad (5)$$

Generally, the company's operational efficiency is affected by more than one indicator, or there are several output indicators. For example, a manufacturing company would be interested in the units produced and earnings as output variables, and the number of employees and the number of shifts as input variables, which leads to the situation where, by using this simplified efficiency formula, it becomes more and more difficult to understand and evaluate the institution's efficiency. In such situations, the DEA method can be used that is able to show which institutions are the most effective ones at certain input and output values (Farrell, Fieldhouse 1962).

Data selection. The article uses the official statistics of the Ministry of Welfare of the Republic of Latvia in the field of social services and social assistance from reports on social services and social assistance in the municipality of the county/Republic at the end of 2017 (Labklajibas ministrija 2019). For the processing of data with the DEA method, 64 long-term municipal social care institutions, which provide services to retirement-age people, and which are registered in the register of social service providers, were selected (Labklajibas ministrija 2019). In a study previously performed by the authors, selected institutions were divided into specific groups using a cluster analysis. Based on the cluster analysis using 12 parameters characterising the 12 institutions, 64 institutions were divided into 3 groups (clusters), where cluster 1 included large LSCIs, cluster 2 included small LSCIs, and cluster 3 included medium-sized institutions (see Table 2):

Table 2

List of LSCIs and their division into clusters

No.	Name of the institution	Cluster
1	**2**	**3**
1	*Balvi* county municipal nursing home *"Balvi"*	1
2	Territorial centre of social services for retired persons of *Daugavpils*	1
3	*Engure* county council's nursing home *"Rauda"*	1
4	*Krustpils* municipal agency *"Jaunā muiža"*	1
5	*Rēzekne* city council administration's social service	1
6	*Rīga* social care centre *"Gaiļezers"*	1
7	*Rīga* social care centre *"Mežciems"*	1
8	Social care centre *"Zemgale"*	1
9	*Talsi* municipal authority "Nursing home *Lauciene*"	1
10	*Gatarta* nursing home	2
11	*Barkava* nursing home	2
12	*Brocēni* municipality social care centre *"Atpūtas"*	2
13	*Cēsis* city nursing home	2
14	*Gulbene* county social care centre *"Siltais"*, unit *"Dzērves"*	2
15	*Gulbene* county social care centre *"Siltais"*	2

Sequel to Table 2 see on the next page

Sequel to Table 2

1	2	3
16	*Gulbene* county social care centre *"Tirza"*	2
17	*Inčukalns* county municipality agency "Social Care House *Gauja*"	2
18	*Jelgava* county social care and rehabilitation centre *"Staļģene"*	2
19	*Jelgava* county social care and rehabilitation centre *"Kalnciems"*	2
20	*Kārsava* county nursing home *"Mūsmājas"*	2
21	*Krāslava* county *Robežnieki* parish administration *Skuķi* Care Centre	2
22	*Krāslava* old people's nursing home *"Priedes"*	2
23	*Ķegums* county social care centre *"Senliepas"*	2
24	*Līvāni* county council's *SIA "Līvānu slimnīca"*	2
25	*Ludza* county social care centre *"Ludza"*	2
26	*Madona* county *Ļaudona* parish administration's *Ļaudona* nursing home	2
27	*Madona* county municipal *Dzelzava* parish nursing home	2
28	*Mālpils* social care centre "*Mālpils* Social Service"	2
29	*Nereta* county municipal *Nereta* social care centre	2
30	Social care centre "*Olaine* Social Service"	2
31	Municipal agency "*Ķekava* Social Care Centre"	2
32	Municipal institution-retirement home *"Sprīdīši"*	2
33	*Preiļi* county welfare administration's nursing home *"Preiļi"*	2
34	*Riebiņi* county social care centre *"Rušona"*	2
35	*Rugāji* county council's social care centre *"Rugāji"*	2
36	Limited liability company "Care House *"Urga"*	2
37	Limited liability company *"Dundagas veselības centrs"*	2
38	*Saldus* county municipal agency social care centre *"Ābeles"*	2
39	*Saulkrasti* municipal institution "Social Care House"	2
40	*Sigulda* county municipal social care house *"Gaismiņas"*	2
41	*Skrunda* county municipal care house *"Valtaiķi"*	2
42	Social care centre *"Alūksne"*	2
43	Social care centre *"Trapene"*	2
44	Social care centre *"Pļaviņas"*	2
45	*Šķilbēni* social care house	2
46	*Umurga* parish old people's residence *"Cerība"*	2
47	*Valka* county council's social care house	2
48	*Varakļāni* county nursing home *"Varavīksne"*	2
49	Old people's residence *"Pēterupe"*	2
50	*Viļaka* social care centre	2
51	"*Jūrmala* Health Promotion and Social Services Centre"	3
52	*Aglona* county municipal institution "Social care centre *"Aglona"*	3
53	*Bauska* county municipal institution "General type nursing home *"Derpele"*	3
54	*Ērgļi* county social care centre	3
55	Municipal *SIA "Veselības un sociālās aprūpes centrs – Sloka"*	3

Sequel to Table 2 see on the next page

Sequel to Table 2

1	2	3
56	*Rēzekne* county old people's nursing home	3
57	*Rīga* social care centre "Stella Maris"	3
58	Limited liability company *"Rekreācijas centrs "Vīķi"*	3
59	*Skrīveri* county municipal agency "Social care centre *"Ziedugravas"*	3
60	*Valmiera* city municipal nursing home *"Valmiera"*	3
61	Elderly and disabled people's nursing home *"Atvasara"*	3
62	*Ventspils* social care home *"Selga"*	3
63	General type nursing home *"Madliena"*	3
64	*Višķi* social care centre	3

Source: created by the authors.

36 separate economic indicators are available for each of these institutions, while the DEA analysis includes 8 indicators for the individual economic positions of institutions as the input and output values:

- number of healthcare professionals (per shift);
- caregivers, nurses and social educators;
- other employees of the institution;
- number of bed-days at the end of 2017;
- total expenses, EUR;
- total OPEX expenses, EUR;
- remuneration costs;
- total number of employees (per shift).

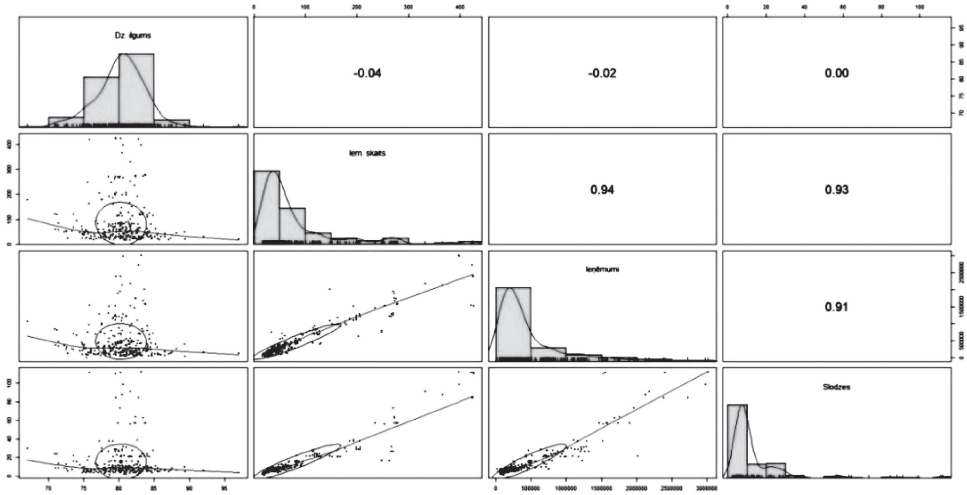
These indicators are selected for analysis because they are the most representative of the quality of care, the material benefit of the employees and the economic activity of the institution.

The life expectancy of residents, which could logically be assumed as an efficiency indicator, is not included in the analysis on the basis of the earlier study performed by the authors, according to which the lifespan of residents did not prove statistically useful (see Figure 1).

The correlation matrix shows that the correlation is the ratio between revenue and shifts, revenue and the number of inhabitants, as well as shifts and the number of inhabitants, but these parameters do not correlate with the average life expectancy of LSCI residents.

Figure 1

Correlation matrix



Source: created by the authors.

2. Analysis of research results

Since no formal benchmarks have been established that should be included in the effectiveness assessment of a specific industry, the authors have chosen to create four separate DEA models. The reason for choosing four models is as follows:

The effectiveness ratios of a model based on output values can take values from 0 to 1. Since several indicators are used, the indicators are not mutually comparable.

For example, if institution X, when looking at a particular indicator, accepts value 1, but institution Y in this index is estimated to be 0.5, then according to that particular indicator institution X is more effective. However, there may be a situation where, according to another indicator, institution Y is valued at 1, but institution X is valued at only 0.7, so it cannot be said that institution Y is more effective than institution X or vice versa, because in these cases these relationships are not comparable.

On the basis of the above, the four DEA models that have been developed provide for technical and cost effectiveness. Technical effectiveness is related to the provision of human resources and the volume of services – in this case, bed-days, while cost effectiveness is related to the optimal use of finances and money (Konstante 2013).

The number of bed days dominates the models as an output parameter. This indicator was chosen based on the publications of individual authors on the application of DEA in the health care system (Souza et al. 2014).

When defining the most effective LSCI institution according to the economic indicators mentioned in the first chapter, several institutions with the effectiveness ratio (1) were obtained in the first three DEA models. These results could be enough because they are natural, as several input indicators are used. However, due to the set goal of

determining the most effective institution, the second iteration was carried out within the scope of the models, where only those LSCIs whose effectiveness ratio was higher than a certain value were analysed and selected. The selected LSCIs were compared based on another criterion, thus obtaining new effectiveness ratios with a single most effective institution.

Model 1.

First iteration – technical effectiveness.
Input values:

- number of healthcare professionals (per shift);
- caregivers, nurses and social educators (by shift);
- other employees of the institution (by shift).

Output value:

- number of bed-days at the end of 2017.

Second iteration – cost effectiveness (institutions with the effectiveness ratio higher than 0.9 are kept).
Input values:

- total expenses, EUR.

Output value:

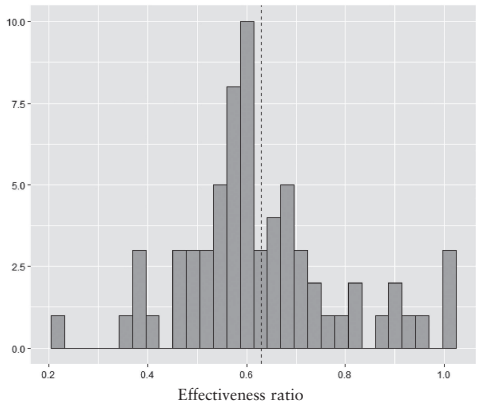
- number of bed-days at the end of 2017.

The Figure shows the distribution of effectiveness ratios for the Model 1 after the first iteration (see Figure 2).

The graph shows the second iteration of the Model 1, which was made based on one input value (total expenses, EUR) and one output value (number of bed days at the end of 2017). This clearly shows the most effective institution (see Figure 3).

Figure 2

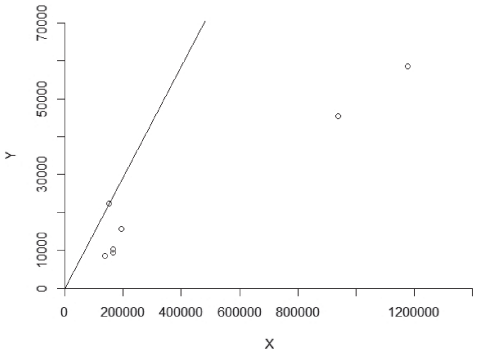
Distribution of the Model 1 coefficients in LSCI



Source: created by the authors.

Figure 3

LSCIs expenses vs. the number of bed-days



Source: created by the authors.

Table 3

LSCIs effectiveness ratios and division into clusters for DEA Model 1

Name of the institution	County	Cluster	EFF 1	EFF 2
Līvāni county council's *SIA "Līvānu slimnīca"*	*Līvāni* county	2	1.00	0.42
Rīga social care centre "Stella Maris"	*Rīga*	3	1.00	0.68
Rugāji county council's social care centre *"Rugāji"*	*Rugāji* county	2	0.91	0.16
Šķilbēni social care house	*Viļaka* county	2	0.96	0.17
Valka county council's social care house	*Valka* county	2	0.93	0.53
Ventspils social care home *"Selga"*	*Ventspils*	3	0.91	1.00
Viļaka social care centre	*Viļaka* county	2	1.00	0.20

Source: created by the authors.

The Table shows the results after both iterations, thus determining the most effective institution according to the Model 1, and shows 7 institutions out of 64 whose effectiveness (EFF1) is not less than (0.9) after the first iteration. These LSCIs were included in the second iteration setting their coefficient as EFF2, and the compliance of LSCI with a particular cluster group is shown (see Table 3).

Summary of results. After the first iteration, evaluating 64 LSCIs based on the technical effectiveness by using the DEA method, the 7 most effective institutions were determined, while 3 of them – *Līvāni* county council's *SIA "Līvānu slimnīca"*, *Rīga* social care centre "Stella Maris" and *Viļaka* social care centre – showed the highest score. After the second iteration which included only these 7 institutions, after evaluating the cost effectiveness, a single most effective institution was determined – *Ventspils* Social Care House *"Selga"*.

It should be noted that the most effective institutions include the 2nd cluster (small) and the 3rd cluster (medium) institutions, and the 3rd cluster's two institutions are the most effective according to the Model 1 iteration.

Model 2.

First iteration – technical effectiveness.
Input values:

- number of healthcare professionals (per shift);
- caregivers, nurses and social educators (by shift);
- other employees of the institution (by shift).

Output value:

- number of bed-days at the end of 2017.

Second iteration – cost effectiveness (institutions with the effectiveness ratio higher than 0.9 are kept).
Input values:

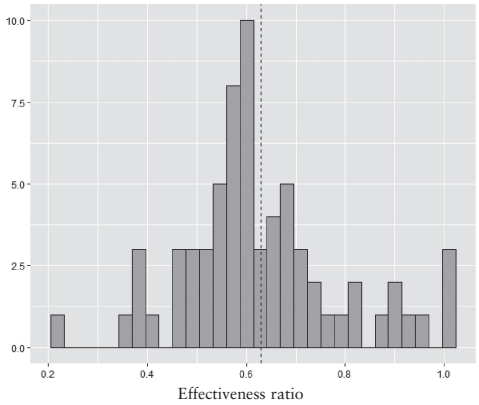
- total OPEX expenses, EUR (OPEX – operating expenses, costs directly related to economic activity).

Output value:

- number of bed-days at the end of 2017.

Figure 4

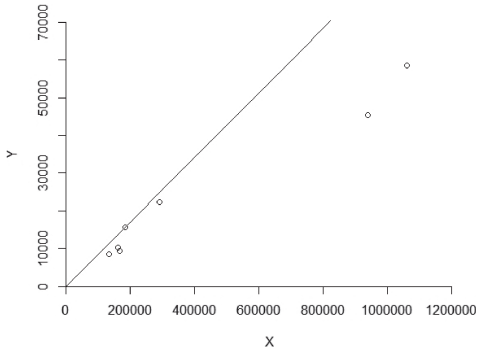
Distribution of the Model 2 coefficients in LSCIs



Source: created by the authors.

Figure 5

OPEX expenses vs. the number of bed-days



Source: created by the authors.

The Figure shows the distribution of effectiveness ratios for the Model 2 after the first iteration, which is the same as the depiction of Model 1, since the same parameters are used (see Figure 4).

The graph depicts Model 2 optimisation after the second iteration, which determines EFF2 according to the total OPEX expenses in euros and the number of bed-days at the end of 2017 (see Figure 5).

Table 4

LSCIs effectiveness ratios and division into clusters for DEA Model 2

Name of the institution	County	Cluster	EFF 1	EFF 2
Līvāni county council's *SIA "Līvānu slimnīca"*	*Līvāni* county	2	1.00	1.00
Rīga social care centre "Stella Maris"	*Rīga*	3	1.00	0.56
Rugāji county council's social care centre *"Rugāji"*	*Rugāji* county	2	0.91	0.66
Šķilbēni social care house	*Viļaka* county	2	0.96	0.74
Valka county council's social care house	*Valka* county	2	0.93	0.90
Ventspils social care home *"Selga"*	Ventspils	3	0.91	0.65
Viļaka social care centre	*Viļaka* county	2	1.00	0.73

Source: created by the authors.

The Table shows the results after both iterations, determining the most effective institution according to the Model 2, and shows 7 institutions out of 64, whose EFF1 was not less than (0.9) after the first iteration. Just like in the Model 1, these LSCIs were included in the second iteration setting their coefficient as EFF2. The Table also shows compliance of LSCIs with a particular group of clusters (see Table 4).

Summary of results. Since the input and output values of the Model 2 first iteration are identical to those of the Model 1, the results of the Model 2 first iteration EFF1 are also similar.

However, after the second iteration, where cost effectiveness was determined and the input values are total OPEX expenses, while the output value is the number of bed-days at the end of 2017, *Līvāni* County Council *SIA "Līvānu slimnīca"* (*Līvāni* Hospital) long-term social care and social rehabilitation unit was identified as the most effective institution, which showed the most efficient ratio even after EFF1. This institution is included in the second cluster group, belonging to small municipal LSCIs.

Model 3.

First iteration – cost effectiveness:
Input values:

- number of healthcare professionals (per shift);
- caregivers, nurses and social educators (by shift);
- other employees of the institution (by shift);
- total expenses, EUR.

Output value:

- number of bed-days at the end of 2017.

Second iteration – cost effectiveness (institutions with the effectiveness ratio higher than 0.95 are kept).
Input values:

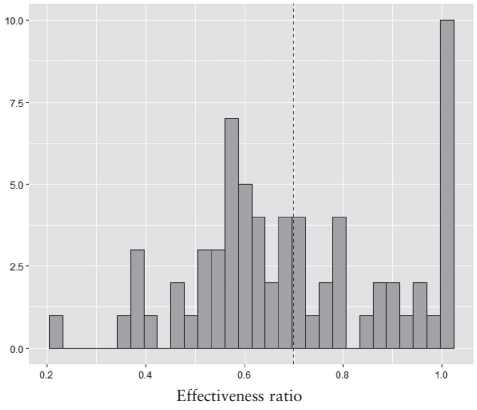
- total number of employees (per shift).

Output value:

- remuneration costs.

Figure 6

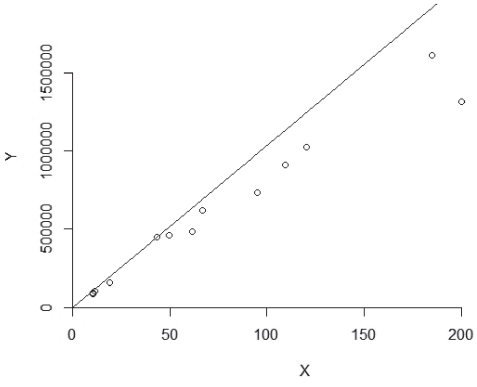
Distribution of the Model 3 coefficients in LSCIs



Source: created by the authors.

Figure 7

Total number of employees (per shift) vs. remuneration cost



Source: created by the authors.

The Figure shows the distribution of effectiveness ratios for the Model 3 after the first iteration. Since this model had more input values than the first two ones, we can see that there are more institutions with the maximum effectiveness ratio, a total of 10 out of 64 LSCIs (see Figure 6).

The graph depicts the Model 3 optimisation graph line after the second iteration, where EFF2 is calculated based on the total number of employees by shift vs. remuneration costs (see Figure 7).

Table 5

LSCIs effectiveness ratios and division into clusters for DEA Model 3

Name of the institution	County	Cluster	EFF 1	EFF 2
"*Jūrmala* Health Promotion and Social Services Centre"	*Jūrmala*	3	0.96	0.90
Bauska county municipal institution "General type nursing home *"Derpele"*	*Bauska* county	3	1.00	1.00
Territorial centre for social services of retired persons of *Daugavpils*	*Daugavpils*	1	1.00	0.74
Engure county council's nursing home *"Rauda"*	*Engure* county	1	1.00	0.63
Līvāni county council's *SIA "Līvānu slimnīca"*	*Līvāni* county	2	1.00	0.76
Rīga social care centre *"Gaiļezers"*	*Rīga*	1	1.00	0.84
Rīga social care centre *"Mežciems"*	*Rīga*	1	1.00	0.82
Rīga social care centre "Stella Maris"	*Rīga*	3	1.00	0.76
Social care centre *"Zemgale"*	*Ozolnieki* county	1	1.00	0.80
Šķilbēni social care house	*Viļaka* county	2	0.96	0.86
Valka county council's social care house	*Valka* county	2	0.99	0.80
Ventspils social care home *"Selga"*	*Ventspils*	3	1.00	0.90
Viļaka social care centre	*Viļaka* county	2	1.00	0.89

Source: created by the authors.

The Table shows the results after both iterations, determining the most effective institution according to the third model, and shows 13 institutions out of 64. However, in this case, after obtaining the results, LSCIs were selected whose EFF1 was not less than (0.95) after the first iteration. These 13 institutions were included in the second iteration resulting in a single most effective institution. As before, the table also shows compliance of LSCIs with a particular cluster group (see Table 5).

Summary of results. Compared to the first two models, where the effectiveness was measured from the institution's point of view, the effectiveness evaluation in the Model 3 was based on employee remuneration vs. shifts. When using the additional cost effectiveness calculation in the second iteration against given LSCIs by determining their EFF2 ratio, the most effective institution according to the Model 3 was the *Bauska* county municipal institution "General Type Nursing Home *"Derpele"*, which even after the first iteration was among the institutions with the highest effectiveness indicator. It should be noted that the second most effective institution according to this model was *Ventspils* Social Care House *"Selga"*. Both of these institutions belong to the third cluster group, i.e. medium-sized nursing homes.

Model 4.

First iteration – cost effectiveness:
Input values:

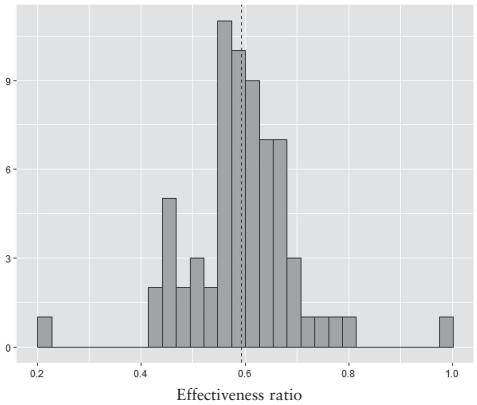
- total number of employees (per shift).

Output value:

- remuneration costs.

Figure 8

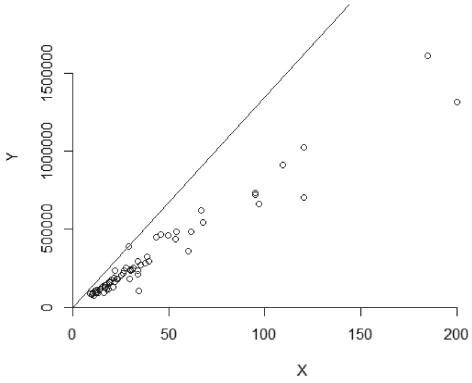
Distribution of the Model 4 coefficients in LSCIs



Source: created by the authors.

Figure 9

Total number of employees (per shift) vs. remuneration cost



Source: created by the authors.

The Figure shows the distribution of effectiveness ratios for the Model 4 after the first iteration. As this model only has one input and one output value, only one institution out of 64 LSCIs was determined to have the most effective indicator (see Figure 8).

Contrary to the previous models, this graph depicts the result after the first iteration, as EFF2 was not used in this model. The graph visualises the relation between indicators of the institutions and the line of the optimal institution. Therefore, EFF1 was calculated according to the total number of employees by shift and remuneration costs (see Figure 9).

The Table depicts 10 institutions out of 64 LSCIs, whose EFF after applying the DEA was among the 10 most effective institutions. Since a single institution with the coefficient (1) was displayed instantly, it was not necessary to perform an additional iteration to clarify EFF2. Additionally, the relevant cluster groups were also indicated (see Table 6).

Table 6

LSCIs effectiveness ratios and division into clusters for DEA Model 4

Name of the institution	County	Cluster	EFF
Municipal agency "*Ķekava* Social Care Centre"	*Ķekava* county	2	1.00
Social care centre "*Olaine* Social Service"	*Olaine* county	2	0.80
Bauska county municipal institution "General type nursing home *"Derpele"*	*Bauska* county	3	0.77
Valmiera city municipal nursing home *"Valmiera"*	*Valmiera*	3	0.75
Municipal institution-retirement home *"Sprīdīši"*	*Salacgrīva* county	2	0.71
"*Jūrmala* Health Promotion and Social Services Centre"	*Jūrmala*	3	0.69
Ventspils social care home *"Selga"*	*Ventspils*	3	0.69
Viļaka social care centre	*Viļaka* county	2	0.69
Gulbene county social care centre *"Tirza"*	*Gulbene* county	2	0.68
Gulbene county social care centre *"Siltais"*	*Gulbene* county	2	0.68

Source: created by the authors.

Summary of results. Unlike the other DEA models, the cost effectiveness Model 4 included only one indicator – total number of employees by shift and one output indicator: remuneration costs. In the DEA model, based on the result where a single most effective institution was instantly displayed, the second iteration was not performed. In this model, the LSCI with the highest EFF was the municipal agency "*Ķekava* Social Care Centre", which dominates quite strongly against the rest of the LSCIs. *Ķekava* Social Care Centre is included in the second group of clusters.

Conclusions

1. Creating DEA models based on several input parameters resulted in displaying several institutions with the highest effectiveness ratio, while using a single input and output parameter produced a single most effective institution.
2. Changing the input and output parameters of institutions also changed the list of the most efficient institutions, where one model was dominated by a particular institution according to certain parameters, while another LSCI was more efficient in another model with different parameters.
3. It may be concluded that determining a single most effective institution based on variable input and output values attributed to LSCIs is not objective as the input parameters are not mutually comparable. This means that, in each model, a particular institution is more effective based on a certain parameter.
4. Regardless of the fact that changing the input and output values will also change the most effective institution, different models showed similar LSCIs as the institutions with the highest EFF.
5. Six of the seven most effective institutions of the Model 1 and 2 also appeared in the Model 3, while two LSCIs of the Model 3 were found among the most effective ones in the Model 4.

6. Only two institutions out of 64 LSCIs in all four DEA models showed the most effective results – *Ventspils* social care house *"Selga"* and *Viļaka* social care centre. In the Model 1, *Ventspils* social care house *"Selga"* was the most effective one by cost effectiveness, and the technical effectiveness results were also good. In the Model 3, *Ventspils* social care house *"Selga"* showed the second best cost effectiveness result.
7. In all four models, the most effective institutions were included in cluster 2 and 3, which contain small and medium-sized LSCIs, meaning that the institutions of this group were more effective in terms of technical and cost effectiveness than the large care centres.

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