Investigaciones Regionales - Journal of Regional Research
ISSN: 1695-7253
ISSN: 2340-2717
investig.regionales@aecr.org
Asociación Española de Ciencia Regional
España

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Investigaciones Regionales - Journal of Regional Research, núm. 53, 2022, Septiembre, pp. 117-133
Asociación Española de Ciencia Regional
Madrid, España

DOI: https://doi.org/10.38191/iirr-jorr.22.013

Disponible en: https://www.redalyc.org/articulo.oa?id=28972371006

Journal of Regional Research
Investigaciones Regionales

ISSN: 1695-7253 e-ISSN: 2340-2717
investig.regionales@aecr.org
AECR - Asociación Española de Ciencia Regional
www.aecr.org
España – Spain

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Available on the website: https://investigacionesregionales.org/numeros-y-articulos/consulta-de-articulos

Additional information:

To cite this article: Campos-Lucena, M.S, Ruiz-Gándara, A, Perez-Nimo, M.M, Ortega-Irizo, F.J, & Velasco-Morente, F (2022). Resource use efficiency level of public organizations. The case of Spanish health systems. Investigaciones Regionales – Journal of Regional Research 2022/2(53), 117-133. https://doi.org/10.38191/iirr-jorr.22.013

Investigaciones Regionales – Journal of Regional Research (2022/2) 53: 117-133
https://doi.org/10.38191/iirr-jorr.22.013

Articles

Resource use efficiency level of public organizations. The case of Spanish health systems

María Soledad Campos Lucena, África Ruiz-Gándara**, María de Magdala Pérez Nimo***, Francisco Javier Ortega Irizo****, Francisco Velasco Morente******

Received: 17 February 2022
Accepted: 20 April 2022

Abstract:

Objectives: This paper seeks to detect, in the Spanish health system, which health services are efficient, and which are not, as well as propose corrective measures that allow inefficient health services to achieve efficiency. Methods: This paper applies the Data Envelopment Analysis (DEA) methodology, which allows obtaining natural and managerial efficiencies, as well as deviations from inefficient units in relation to efficient ones and proposing corrective measures that imply only budgetary (natural) modifications or changes in the policies of resource management (management).

Results: Through the efficiencies, or the lack of them, the health services of the 17 Spanish autonomous communities are classified into four groups: With high, medium-high, medium-low or low natural or managerial efficiency.

Conclusions: The lack of natural efficiency can be corrected with a greater budgetary endowment and the lack of managerial efficiency with a budget cut and changes in resource management policies. This tendency contrary to the adjustments is precisely what gives this work of interest and novelty with respect to others that apply the DEA in different sectors such as those that study the impact on the environment of resource consumption. Another important aspect of this study is the possibility of applying it to other countries with similar political structures.

Keywords: Data envelopment analysis; natural efficiency; managerial efficiency; cluster analysis; Spanish Health System.
JEL Classification: C4; C5; C6.

Nivel de eficiencia del uso de recursos por las organizaciones públicas. Caso: Sistemas Sanitarios Españoles

Resumen:

Objetivos: Con este trabajo se persigue detectar, en el sistema sanitario español, que servicios sanitarios son eficientes y cuáles no, así como proponer medidas correctoras que permitan a los servicios sanitarios ineficientes alcanzar la eficiencia.

Metodología: Este trabajo aplica la metodología del análisis envolvente de datos (DEA), que permite obtener las eficiencias natural y gerencial, así como las desviaciones de las unidades ineficientes con relación a las eficientes, y proponer medidas correctoras que impliquen únicamente modificaciones presupuestarias (natural) o cambios en las políticas de gestión de recursos (gerencial).

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Resultados: A través de las eficiencias, o la falta de ellas, los servicios sanitarios de las 17 comunidades autónomas españolas se clasifican en cuatro grupos: Con eficiencia natural o gerencial alta, media-alta, media-baja o baja.
Conclusiones: La falta de eficiencia natural puede corregirse con una mayor dotación presupuestaria, la falta de eficiencia gerencial con un recorte presupuestario y cambios en las políticas de gestión de recursos. Esta tendencia contraria de los ajustes es precisamente la que dota este trabajo del interés y novedad con respectos a otros que aplican el DEA en sectores diferentes como aquellos que estudian el impacto en el medioambiente de los consumos de recursos. Otro aspecto importante de este estudio es la posibilidad de aplicarlo a otros países con estructuras políticas similares.

PALABRAS CLAVE: Análisis envolvente de datos; eficiencia natural; eficiencia gerencial; análisis clúster; Sistema Nacional de Salud.

CLASIFICACIÓN JEL: C4; C5; C6.

1. INTRODUCTION

Throughout history, public participation in the various economic sectors has been a bone of contention argued over by the supporters of public ownership and the free market. Despite of this, public participation in some specific economic sectors such as health has become a fundamental premise in developed States, and this sparks further debate on the suitability of the public sector's breadth of intervention or investment.

In the case of public administrations, once public resources have been allocated, the estimated amount of revenue places a limit on public expenditure with no further expenditure having to be incurred for income to be raised.

This limitation has dual implications. First, the expenses that are to be met need to be prioritized, with the available resources allocated according to the needs determined to be the most important. Second, the decision to use more or fewer resources on a specific expense implies limiting to a greater or lesser extent the resources that can be devoted to other expenses. All this makes effective and efficient management of public resources essential.

The Spanish health system is considered to be the most efficient in Europe and the third most efficient in the world after Hong Kong and Singapore (Bloomberg Report 2018). The Bloomberg Report measures the efficiency of health systems by life expectancy, per capita spending on health and the percentage of GDP spent on health.

According to the Euro Health Consumer Index report1, Spanish health is in nineteenth place with 698 points, behind Serbia and Slovakia. The report highlights the fact that the Spanish health system is "very regionally decentralized".

The Spanish health system is decentralized. It is implemented by the country's autonomous regions—the seventeen autonomous communities (CAs), all of which operate their own independently-managed health services, which can, therefore, be compared and improved.

The purpose of this study is to detect the Spanish health services that are efficient and those that are not. Measures are then proposed that can be implemented by any health services that are inefficient for them to be able to achieve a level of efficiency and, consequently, help improve the Spanish health system overall.

2. METHODOLOGY

According to González et al. (2010), an efficiency study can be approached in two ways, with either the use of management measures based on ratio analysis, which can generate contradictory results depending on the indicators (Goddard et al., 2003) used or, alternatively, on the use of global efficiency indexes.

The latter include Data Envelopment Analysis (DEA), which is a management approach to evaluate operations in organizations in both the public and private sectors (Lowell et al. 2003). The popularity of this method can be seen in Emrouznejad et al. (2008). The history of DEA is described by Glover et al. (2009) based on the contributions of Cooper et al. (2001), while Ijiri et al. (2010) describe the philosophical background of accounting and the economy around which DEA came to pivot. Numerous studies of environmental issues have been published in recent years. (Cooper et al., 2001; Zhou et al., 2008; Sueyoshi et al., 2011; Sueyoshi et al., 2012; Sueyoshi et al., 2013; Sueyoshi et al., 2014).

Many publications have applied the DEA model with a range of variations since it first emerged out of the work by Farrell (1957). These have included approaches from the angle of both the inputs and the outputs depending on the controlled variable (Campos-Lucena et al., 2013) and included a distinction between good and bad outputs according to the efficiency achieved by raising or reducing their numbers. (Sueyoshi et al., 2011; Campos-Lucena et al., 2013; Campos-Lucena et al., 2018; Expósito et al., 2020)

It is important to differentiate between the natural and managerial character of the input variables. Unlike what occurs with other types of organizations, the natural variation in allocated resources in a health system means that any increase in the allocated budget must inherently lead to an improvement in outcomes. In contrast, managerial variation implies that the obtained results are compelled to improve when fewer resources are allocated, and different managerial policies applied.

With respect to the outputs, a distinction must be made between those that are considered to be good and improve the organization's efficiency, and those that are bad and improve efficiency when they are eliminated.

The model proposed (Sueyoshi et al., 2012) can be used to calculate the slope of the marginal productivity curve. This determines the variability of the Return to Scale (RTS) for good outputs and the Damage to Scale (DTS) for bad outputs.

The model seeks a radial focus and to solve it SCSC (Strong Complementary Slackness Condition) (Sueyoshi et al., 2012) has been applied, requiring the corresponding two problems to be obtained.

In our DEA models (Sueyoshi et al., 2012), Natural and Managerial, each j-th DMU $j = 1, \dots n$, uses inputs $X_j = (x_{1j}, \dots, x_{mj})^T$ and generates desirable (good) outputs, represented by $G_j = (g_{1j}, \dots, g_{sj})^T$, and undesirable (bad) outputs, represented by $B_j = (b_{1j}, \dots, b_{hj})^T$. Furthermore, $d_i^x, i = 1, \dots m$, $d_r^g, r = 1, \dots, s$, and $d_f^b, f = 1, \dots, h$ represent slack variables related to inputs, and desirable and undesirable outputs, respectively. $\lambda = (\lambda_1, \dots, \lambda_n)^T$ are unknown structural or intensity variables, which are used for connecting the input and output vectors via a convex combination. R is the range resolute throughout the upper and lower bounds of inputs, desirable outputs and undesirable outputs, and is expressed by following expressions:

$$R_i^x = (m + s + h)^{-1}\left(\max\{x_{ij} | j=1, \dots, n\} - \min\{x_{ij} | j=1, \dots, n\}\right)^{-1}$$

$$R_r^g = (m + s + h)^{-1}\left(\max\{g_{rj} | j=1, \dots, n\} - \min\{g_{rj} | j=1, \dots, n\}\right)^{-1}$$

$$R_f^b = (m + s + h)^{-1}\left(\max\{b_{fj} | j=1, \dots, n\} - \min\{b_{fj} | j=1, \dots, n\}\right)^{-1}$$

Following the DEA study, a cluster analysis is performed in order to create groups according to natural efficiency and managerial efficiency, which will be explained in the results. The cluster analysis has been carried out using the IBM SPSS Statistics 26 software.

a. Natural-health model

Our health model is based on the Sueyoshi et al. (2012) study but with substantial differences. The natural model proposed by Sueyoshi implies that a reduction in inputs results in a natural adjustment of bad Outputs. However, the natural-health model proposed in this study implies that an increase in the Inputs results in a natural increase in the good Outputs that must rise in number and a reduction in the bad Outputs that have to decrease, and that this leads to an improvement in the obtained results.

Analytically:

$$Max \quad \sum_{i=1}^{m} R_i^x \, d_i^x + \sum_{r=1}^{s} R_r^g \, d_r^g + \sum_{f=1}^{h} R_f^b \, d_f^b \tag{1}$$

Subject to

$$\sum_{j=1}^{n} x_{ij} \, \lambda_j - d_i^x = x_{ik} \quad (i = 1, \dots, m),$$

$$\sum_{j=1}^{n} g_{rj} \, \lambda_j - d_r^g = g_{rk} \quad (r = 1, \dots, s),$$

$$\sum_{j=1}^{n} b_{fj} \, \lambda_j + d_f^b = b_{fk} \quad (f = 1, \dots, h),$$

$$\sum_{j=1}^{n} \lambda_j = 1, \; \lambda_j \geq 0 \quad (j = 1, \dots, n),$$

$$d_i^x \geq 0 \; (i = 1, \dots, m), d_r^g \geq 0 \; (r = 1, \dots, s), \text{ and } d_f^b \geq 0 \; (f = 1, \dots, h).$$

Model (1) considers only deviations $-d_i^x, \; (i = 1, \dots, m)$ to attain the natural disposability.

Its solution provides the necessary efficiency scores, measured by:

$$\theta^* = 1 - \left(\sum_{i=1}^{m} R_i^x \, d_i^{x*} + \sum_{r=1}^{s} R_r^g \, d_r^{g*} + \sum_{f=1}^{h} R_f^b \, d_f^{b*} \right)$$

The equation within the parenthesis, obtained from the optimality of Model (1), indicates the level of inefficiency under natural disposability.

b. Managerial-health model

The managerial-health model (Sueyoshi et al., 2012) implies that the increase in efficiency is linked to changes in the management policies that enable the number of resources consumed to be increased while the number of bad Outputs generated is reduced.

In the case of the managerial-health model proposed in this study, the reduction in inputs or resource used must result in no reduction in desirable Outputs by virtue of good management and the fact that the non-desirable outputs must be reduced for efficiency to be improved.

Analytically:

$$Max \quad \sum_{i=1}^{m} R_i^x \, d_i^x + \sum_{r=1}^{s} R_r^g \, d_r^g + \sum_{f=1}^{h} R_f^b \, d_f^b \tag{2}$$

Subject to

$$\sum_{j=1}^{n} x_{ij} \, \lambda_j + d_i^x = x_{ik} \quad (i = 1, \dots, m),$$

$$\sum_{j=1}^{n} g_{rj} \, \lambda_j - d_r^g = g_{rk} \quad (r = 1, \dots, s),$$

$$\sum_{j=1}^{n} b_{fj} \, \lambda_j + d_f^b = b_{fk} \quad (f = 1, \dots, h),$$

$$\sum_{j=1}^{n} \lambda_j = 1, \; \lambda_j \geq 0 \quad (j = 1, \dots, n),$$

$$d_i^x \geq 0 \; (i = 1, \dots, m), d_r^g \geq 0 \; (r = 1, \dots, s), \text{ and } d_f^b \geq 0 \; (f = 1, \dots, h).$$

Model (2) considers only deviations $+d_i^x, (i = 1, \dots, m)$ to attain the natural disposability.

Its solution provides the necessary efficiency scores, measured by:

$$\theta^* = 1 - \left(\sum_{i=1}^{m} R_i^x \, d_i^{x*} + \sum_{r=1}^{s} R_r^g \, d_r^{g*} + \sum_{f=1}^{h} R_f^b \, d_f^{b*} \right)$$

The equation within the parenthesis, obtained from the optimality of Model (2), indicates the level of inefficiency under managerial disposability.

The variables used have been taken from the Spanish National Health System Key Indicators Database (Bases de Datos de Indicadores Clave del Sistema Nacional de Salud: INCLASNS [2019]). The study has been carried out using 2016 data. The Inputs used are territorialized public health expenditure per protected citizen (Input 1); territorialized public health devoted to training, per citizen (Input 2), and

territorialized public health expenditure devoted to outsourcing per protected citizen (Input 3). These three variables cover almost the entire expenditure of the autonomous communities' health services on health. Numerous studies can be found that use similar variables. (Hadad et al., 2013)

These Input variables have been selected on the basis of the major ongoing debate around the appropriateness or inappropriateness of outsourcing or privatizing services, (Moschuris et al., 2006; Hodge et al., 2007; Girth et al., 2012; Alonso et al., 2015; Choi et al., 2016) and the need to invest in training and research (Hartley, 2005; Glasgow et al., 2012; McKee et al., 2012; Begley et al., 2015; El-Noush et al., 2015; Thune et al., 2016).

The following Outputs have been selected: the degree of civic satisfaction with the way that the public health system works (Output 1–Good) and the general mortality rate adjusted for age, per 100,000 inhab. (Output 2–Bad), to represent user perception of the quality of the health services. The latter is also recognized to be an indicator of the quality of health services (Wiley et al., 2016) by the World Health Organization. Earlier works therefore also exist that use these outputs as adequate measures of efficiency (Donghua et al., 2008; Adang et al., 2007; Clement et al., 2008).

3. Results

According to the models based on studies (Sueyoshi et al., 2012) were applied to the variables explained. The corresponding data are given in Table 1.

Table 1.
Original data used in this study.

Autonomous Community		Input 1	Input 2	Input 3	Output-G	Output-B
1	Andalusia (AN)	1160,65	22,632675	47,238455	6,39	491,77
2	Aragon (AR)	1577,52	21,454272	61,838784	7,25	426,75
3	Asturias, Principality of (AS)	1595,83	27,288693	97,824379	6,97	472,75
4	Balearic Islands (IB)	1379,63	19,728709	144,171335	6,86	438,08
5	Canary Islands (CN)	1432,9	22,49653	138,41814	5,99	468,68
6	Cantabria (CB)	1487,19	36,882312	53,687559	7,05	441,14
7	Castile and Leon (CL)	1523,55	27,271545	59,266095	6,91	408,12
8	Castile - La Mancha (CM)	1382,27	21,148731	69,528181	6,34	429,91
9	Catalonia (CT)	1423,64	13,239852	356,052364	6,35	422,34
10	Valencia, Community of (VC)	1411,18	25,260122	59,128442	6,41	456,49
11	Extremadura (EX)	1592,59	23,411073	70,07396	6,51	473,74
12	Galicia (GA)	1464,29	25,039359	86,685968	6,35	455,89
13	Madrid, Community of (MD)	1237,23	32,044257	132,507333	6,73	374,69
14	Murcia, Region of (MC)	1552,63	29,344707	103,094632	6,91	457,82
15	Navarre, Community of (NC)	1587,02	21,742174	115,693758	7,29	409,73
16	Basque Country (PV)	1652,63	27,598921	111,883051	6,86	421,24
17	La Rioja (RI)	1406,59	23,068076	110,135997	7,23	407,73

Source: Prepared by authors.

The results obtained from applying the model (Sueyoshi et al., 2012) can be examined in detail in annexes I and II, note that the programming of the DEA models is done using linear programming in Mathematica 12.3. The first column of both tables indicates natural or managerial efficiency, respectively, taking a value between 0 and 1 being 1 efficiency. Columns I1, I2, I3 deviations indicate the increase in the budget required to achieve efficiency (value 1 in the first column), in each of the inputs studied. Columns O1, O2 deviations indicate the increase or decrease in the degree of satisfaction and the mortality rate, respectively, when achieving efficiency.

Linked to the variation in resources invested in the various health systems, the effect that this variation has on the results has to be taken into account. For this, the Return to Scale (RTS) should be observed that indicate the effect that any variation in the Inputs has on the Output-G (good Outputs). This rate could be increasing, constant, or decreasing, which implies that any variation in the Inputs causes a variation in the Output-G that is proportionally greater, proportionally the same, or proportionally smaller, respectively.

The Damage to Scale (DTS) that link the variation in Inputs to the variability of the Output-B (bad Outputs) also need to be considered. As with the RTS, any variation in the Inputs causes variations in the Output-B that are proportionally greater, the same or smaller.

Annex I (column RTS and DTS) show the increases that these health services require to their health care budgets. These increases would impact on their Outputs and ensure that their production functions are in line with the set of health services that are part of the efficiency border that the remaining health services should target.

Sueyoshi et al. (2012) address environmental issues. In such a context, any increase in Inputs inherently worsens the results, i.e., there is an increase in bad Outputs and a decrease in good Outputs. This study's context is different. Increasing the Inputs intrinsically raises the good Outputs and reduces the bad Outputs.

The efficiencies calculated with this model should, therefore, be interpreted the other way round, which means that environmental studies dealt with in natural efficiency health system studies should be interpreted as managerial efficiency and vice versa.

Based on the above data and following the grouping taken from the combination of rescaled difference clusters of natural efficiency, health services can be classified into the following groups:

TABLE 2.
Classification of health services by cluster analysis

Autonomous Community		Natural cluster	Managerial cluster
1	Andalusia (AN)	G4	G1
2	Aragon (AR)	G1	G1
3	Asturias, Principality of (AS)	G1	G2
4	Balearic Islands (IB)	G2	G1
5	Canary Islands (CN)	G4	G4
6	Cantabria (CB)	G1	G1
7	Castile and Leon (CL)	G1	G1
8	Castile - La Mancha (CM)	G3	G1
9	Catalonia (CT)	G1	G1
10	Valencia, Community of (VC)	G3	G2
11	Extremadura (EX)	G3	G3
12	Galicia (GA)	G3	G3
13	Madrid, Community of (MD)	G1	G1

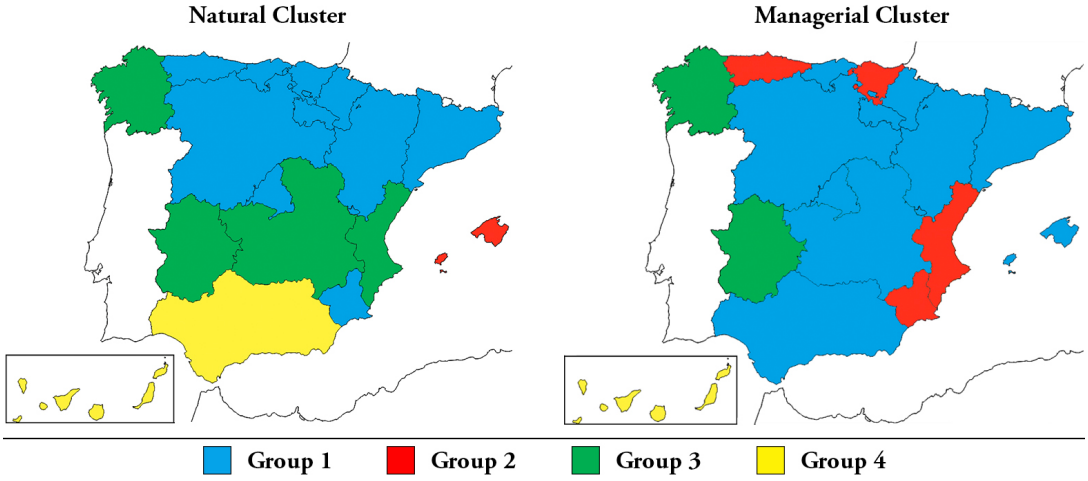
TABLE 2. CONT.
Classification of health services by cluster analysis

14	Murcia, Region of (MC)	G1	G2
15	Navarre, Community of (NC)	G1	G1
16	Basque Country (PV)	G1	G2
17	La Rioja (RI)	G1	G1

Source: Prepared by authors.

As can be observed, applying the two models, natural and managerial, classifies health services into four groups, which will be analyzed in the following.

GRAPHIC 1.
Classification of health services by cluster analysis



Source: Prepared by authors.

GROUP 1: HEALTH SERVICES WITH HIGH NATURAL EFFICIENCY

This group is formed of the health services with either natural efficiency or with minimum health inefficiency as, in the worst case, the service's inefficiency does not reach 1.405382% (Murcia case, see Annex I). These are the health services of the Cantabria, Catalonia, Madrid, Navarre, Basque Country, La Rioja, Castile-Leon, Aragon, Asturias and Murcia CAs.

The first five of these health services are naturally efficient, which implies that they have sufficient resources that are being well-managed.

Also, the Murcia CA health service does not require any increase to its budget and its budget does not need to be redistributed (the value in "I1 deviations", "I2 deviations" and "I3 deviations" are 0). However, its available resources should be better exploited for the results to give a 1.405341% (annex I, column "01 deviations") boost to civic satisfaction and lower the mortality rate by 6.68588% (annex I, column "02 deviations").

The remaining health services are also approaching efficiency, but all require a minimum increase to their budgets, which should have a natural knock-on effect that improves their efficiency. This improvement would result in an increase in Output-G and a decrease in Output-B.

Group 2: Health services with mid-to-high natural efficiency

This group is composed of the Balearic Islands health service alone. The inefficiency of this health service does not reach 0.05. However, it is beginning to deviate from the efficiency of the previous group's health services.

This health service requires a budget increase of around 190€/inhab. (Annex I, columns "I1 deviations" + "I2 deviations"), mostly for health expenditure directly managed by the public service and only a small part allocated to training. If the current management of public resources remains the same, this budget increase would result in a small 0.3186 (annex I, column "01 deviations") improvement in the degree of civic satisfaction and a general 26.8559 (annex I, column "02 deviations") reduction in the age-adjusted mortality rate per 100,000 inhab.

It must be borne in mind that RTS is decreasing, which implies that Output-G variability is less than proportional with respect to the increase in Inputs. This means that, in order to achieve efficiency, a more-than-proportional increase in inputs is required to achieve the desired improvement in the output that requires the increase. DTS is constant, which means that the impact on the improvement in the Output-B is proportional to the budget effort made and, consequently, also on the advantage achieved from this variable.

Group 3: Health services with mid-to-low natural efficiency

This group is formed of health services with a natural efficiency between 0.878165074 (Galicia case, annex I) and 0.905349683 (Castile-La Mancha case, annex I). These are the health services of Castile-La Mancha, Extremadura, Valencia, and Galicia. All these health services have constant RTS and DTS rates. This implies that the increase in resources allotted to their health systems managed both directly by the public service and set aside for training and external contracts with private companies results in a proportional improvement in the results in the form of both an increase in user satisfaction and a reduction in the mortality rate.

These increases in resources and their recommended distribution, which can be observed in detail in annex I, cause a natural improvement in both civic satisfaction with the various health systems and to the age-adjusted mortality rate per 100,000 inhab., and positions the health services of these CAs on the border marked by the production functions that operate efficiently naturally.

Group 4: Health services with low natural efficiency

The health services that form this group are those of Andalusia and the Canary Islands. These health services have an efficiency level of between 0.845352402 and 0.861361693 (see annex I) and require an increase in their budget effort. In the case of Andalusia, an increase of €420.50 (annex I, column "I1 deviations") per protected citizen is required to health expenditure directly managed by the health service and €64.81 (annex I, column "I3 deviations") to health expenditure for external contracts. The increase to the budget required to achieve efficiency in this Autonomous Community is significant (almost €500 per inhabitant).

Depending on the model applied, this increase to the budget will result in a 13.8636% (annex I, column "01 deviations") rise in civic satisfaction with the health system and a 16.3069% (annex I, column "02 deviations") reduction in the mortality rate.

The following table shows in graphic form the variation required in Inputs and Outputs (should any variation be necessary) for health efficiency to be achieved naturally.

None of the adjustments referred to in the previous paragraphs require any changes to their management at all but they do need the resources that they have been allocated to be better exploited with the use of the same procedures.

TABLE 3.
Summary of results of natural-health model application

Autonomous Community		I1 Deviations	I2 Deviations	I3 Deviations	O1 Deviations	O2 Deviations
1	Andalusia (AN)	↑	↔	↑	↑	↓
2	Aragon (AR)	↑	↑	↑	↑	↓
3	Asturias, Principality of (AS)	↔	↔	↑	↑	↓
4	Balearic Islands (IB)	↑	↑	↔	↑	↓
5	Canary Islands (CN)	↔	↑	↔	↑	↓
6	Cantabria (CB)	↔	↔	↔	↔	↔
7	Castile and Leon (CL)	↔	↔	↑	↑	↓
8	Castile - La Mancha (CM)	↔	↑	↑	↑	↓
9	Catalonia (CT)	↔	↔	↔	↔	↔
10	Valencia, Community of (VC)	↑	↔	↑	↑	↓
11	Extremadura (EX)	↔	↔	↑	↑	↓
12	Galicia (GA)	↑	↔	↑	↑	↓
13	Madrid, Community of (MD)	↔	↔	↔	↔	↔
14	Murcia, Region of (MC)	↔	↔	↔	↑	↓
15	Navarre, Community of (NC)	↔	↔	↔	↔	↔
16	Basque Country (PV)	↔	↔	↔	↔	↔
17	La Rioja (RI)	↑	↔	↑	↑	↓

Source: Prepared by authors.

It must be borne in mind that the philosophy that governs the management of public budgets is totally different from the basis for their management in the private sector. In the public sector, administrations have resources that do not depend on expenditure, although these do limit them, i.e., the maximum that budgeted public expenditure can reach is the total amount of budgeted public revenue. This implies that an increase in the budget for any given expenditure causes a reduction in the budget for some other expenditure, which means that although resource management is fundamental in any organization, this is even more the case in the public sector.

For this reason, apart from seeking efficiency in this type of public organizations by way of a higher resource budget, it is desirable for their management to be improved through changes to management policies that lead to a simultaneous savings in resources and better results. This is the reason why this study groups health services together according to the criteria taken from the combination of rescaled difference clusters of managerial efficiency. This enables the health services to be classified into four groups, although this entails different implications:

Group 1: Health services with high managerial efficiency

This first group is the most populated. The health services that comprise this group are the Andalusia, Aragon, Balearic Islands, Cantabria, Castile-Leon, Castile-La Mancha, Catalonia, Madrid, Navarre and La Rioja CAs. These are all health services run with managerial efficiency, which means that the production functions of said health services define the efficiency border that the remaining DMUs must target to achieve efficiency. They all manage their resources efficiently, so no changes are required to their budget management procedures.

In the case of Andalusia, note that it is inefficient by taking into account the natural efficiency, while it is efficient if we take into account the managerial efficiency. This leads to an additional question being posed with regard to the congestion of resources. The law of diminishing marginal returns states that when a given level of resources is reached, excess resources lead to negative returns, i.e., any increase in Inputs can inherently cause a worsening of Outputs due to the management of the former being hampered. This is an issue that will be addressed in a forthcoming study.

Group 2: Health Services mid-to-high managerial efficiency

The second group is composed of health services that, despite not achieving managerial efficiency, have an inefficiency between 0.04277 (Basque country case, annex II) and 0.05246 (Valencia case, annex II). The group includes the health services of Asturias, Valencia, Murcia and the Basque Country. In most cases, for managerial efficiency to be achieved they need to use fewer resources while nonetheless improving the obtained results.

The biggest budget cutback should be made by the Basque Country health service, which needs to make an almost €270 (annex II, columns "I1 deviations" + "I2 deviations") per person cut in its investment in health services. Most of this should be to direct management by the health service with a small reduction to the training of residents. In Asturias and Murcia, only a minimal cutback is required and in Valencia, there is no need for any cutback at all. Nevertheless, in cases where new, reduced budgets are necessary, the health services need to change their resource management policies to achieve better results, raise the level of civic satisfaction and reduce the mortality rate in their respective CAs.

In the specific case of the Basque Country, as the population of this CA was 1,049,555 inhabitants in 2016 (according to the INCLASS database [2019] from which all the other data have been taken), the savings made with a cutback of this type would be approx. €284 million, which could be allocated to some other public services.

Group 3: Health services with mid-to-low managerial efficiency

This group is formed of health services with managerial efficiency between 0.890822407 (Extremadura case, annex II) and 0.894502012 (Galicia case, annex II). In this case, they are the health services of the Galicia and Extremadura CAs. The reduction in the budget is minimal in both cases. In Extremadura, this could represent a saving of almost €27 million (537,391 inhabitants dispersed throughout the territory).

The challenge that this health services face is to improve their management processes, i.e., they have to achieve better results that improve the level of civic satisfaction between 0.7107 (Extremadura case, annex II, column "01 deviations") and 0.7299 (Galicia case, annex II, column "01 deviations") and reduce the mortality rate per 100,000 inhabitants by 48-52 persons, i.e., with the same resources but changing the way that they work.

Group 4: Health services with low managerial efficiency

Lastly, the health system with the poorest managerial efficiency is that of the Canary Islands CA. In this case, no cutback in the budget is required but the obtained results need to be improved with the resources that they have.

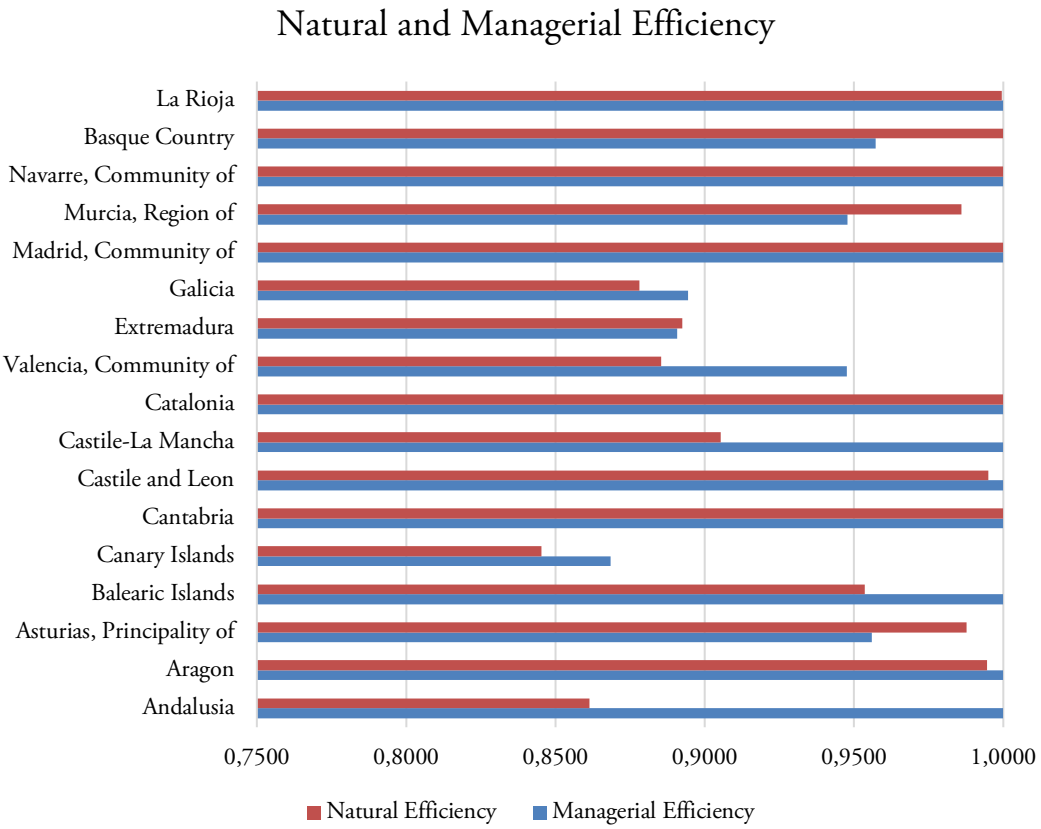
The following table gives a graphic representation of the variations required in inputs and outputs, where these are necessary, to achieve managerial efficiency in health.

TABLE 4.
Summary of results of application of the managerial-health model

Autonomous Community		I1 Deviations	I2 Deviations	I3 Deviations	O1 Deviations	O2 Deviations
1	Andalusia (AN)	↔	↔	↔	↔	↔
2	Aragon (AR)	↔	↔	↔	↔	↔
3	Asturias, Principality of (AS)	↓	↓	↔	↑	↓
4	Balearic Islands (IB)	↔	↔	↔	↔	↔
5	Canary Islands (CN)	↔	↔	↔	↑	↓
6	Cantabria (CB)	↔	↔	↔	↔	↔
7	Castile and Leon (CL)	↔	↔	↔	↔	↔
8	Castile - La Mancha (CM)	↔	↔	↔	↔	↔
9	Catalonia (CT)	↔	↔	↔	↔	↔
10	Valencia, Community of (VC)	↔	↔	↔	↑	↓
11	Extremadura (EX)	↓	↓	↔	↑	↓
12	Galicia (GA)	↔	↔	↔	↑	↓
13	Madrid, Community of (MD)	↔	↔	↔	↔	↔
14	Murcia, Region of (MC)	↔	↓	↔	↑	↓
15	Navarre, Community of (NC)	↔	↔	↔	↔	↔
16	Basque Country (PV)	↓	↓	↔	↑	↓
17	La Rioja (RI)	↔	↔	↔	↔	↔

Source: Prepared by authors.

GRAPHIC 2.
Summary of results of application of natural vs managerial-health model by autonomous community



Source: Prepared by authors.

4. DISCUSSION

Good management of public resources is of vital importance for the proper running of the welfare State. The budget limitations to which the administrations are subjected imply that there is a need to prioritize the investment or expenditure of the resources that they have available. For this reason, this study analyzes the efficiency of the health systems dependent on the CAs in Spain and proposes corrective measures for the inefficient units to achieve efficiency.

The study is based on the application of the DEA model and natural and management efficiency of the health services dependent on the seventeen CAs into which Spain has its territorial organization decentralized. This study extends previous research that has demonstrated the adequacy of the DEA method and allowed researchers to propose corrective measures to achieve overall efficiency in inefficient health systems (Campos et al., 2016) as well as to look for efficiencies can be attained through natural and/or managerial adjustments by increasing the variables that are considered desirable (Campos et al., 2018) arriving at conclusions according to the search for the natural and managerial efficiency.

In the case of natural efficiency, any shortfall can be corrected by making available a higher budget that should be properly managed. This is a fundamental difference from the application made by other studies that apply DEA.

In the case of managerial efficiency, savings to the budget is the main priority. In the specific sector under study, a saving in any given expenditure means an opportunity to increase some other. Managerial

efficiency implies that even when fewer resources are available, a change in the way that things are done means that better results can be obtained.

In short, all the health services that are not managerially efficient have to change the way that they operate. They must change their resource management policies in order to achieve better results with the same or a lower budget.

Specifically, as the data demonstrate that the lack of efficiency is to a great extent the result of mortality rates that must be reduced, the resources that are freed up could be allocated to putting preventive medicine policies into effect, which improves public health; restructuring the team of professionals, tasked with putting a greater effort into the early detection of illness; lower patient waiting times, which can be resolved with improvements to the management of operating rooms; and specialized centers with different schedules, which can bring a halt to delays in the detection of illnesses. More resources could be allotted to research, to improving technology, to talks given by experts on important and especially called-for subjects, to the redistribution of resident staff in line with agreed criteria, to the application of incentivizing policies that motivate residents and to improving labor conditions that enable the greater productivity of residents, etc.

Acknowledgements

Ruiz-Gándara, Pérez-Nimo and Ortega-Irizo acknowledge the funding by The Ministerio de Ciencia, Innovación y Universidades (PGC2018-102145-B-C21) and Velasco-Morente acknowledge the funding by The Ministerio de Economía y Competitividad (TIN2017-82113-C2-1-R).

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Annexes

Annex I

Table 5.
Natural efficiency levels, INPUT 1, 2 and 3 deviations, and OUTPUT 1 and 2 deviations with respect to natural efficiency

Autonomous Community		Natural efficiency	I1 Deviations		I2 Deviations		I3 Deviations		O1 Deviations		O2 Deviations		RTS	DTS
1	Andalusia (AN)	0,861361693	420,4982758	36,229550%	0	0%	64,8082700	137,1938%	0,88588386	13,86359%	-80,192550	-16,3069%	Decreasing	Constant
2	Aragon (AR)	0,994482096	9,5	0,602211%	0,287902	1,341933%	53,854974	87,08931%	0,04	0,551724%	-17,02	-3,98828%	Decreasing	Constant
3	Asturias, Principality of (AS)	0,987764874	0	0%	0	0%	3,93839704	4,025987%	0,08527317	1,223431%	-51,791980	-10,9554%	Constant	Constant
4	Balearic Islands (IB)	0,953551629	188,0328128	13,629220%	1,006113803	5,099745%	0	0%	0,3186292	4,64474%	-26,85597	-6,1303%	Decreasing	Constant
5	Canary Islands (CN)	0,845352402	0	0%	2,907746884	1,925313%	0	0%	1,0085683	16,8375%	-72,48006	-15,464%	Constant	Constant
6	Cantabria (CB)	1	0	0%	0	0%	0	0%	0	0%	0	0%	Decreasing	Increasing
7	Castile and Leon (CL)	0,9949286	0	0%	0	0%	58,4698650	98,65651%	0,03504075	0,50710%	-2,0695852	-0,50710%	Constant	Constant
8	Castile - La Mancha (CM)	0,905349683	0	0%	6,623779757	31,319987%	56,0074234	80,55355%	0,62220332	9,81393%	-40,6907064	-9,46493%	Constant	Constant
9	Catalonia (CT)	1	0	0%	0	0%	0	0%	0	0%	0	0%	Decreasing	Increasing
10	Valencia, Community of (VC)	0,885474936	88,60177742	6,278560%	0	0%	55,5643219	93,97224%	0,73410104	11,45243%	-52,279217	-11,4524%	Constant	Constant
11	Extremadura (EX)	0,892483464	0	0%	0	0%	41,9931506	59,92689%	0,69992980	10,75161%	-60,649526	-12,8022%	Constant	Constant
12	Galicia (GA)	0,878165074	19,92984754	1,361059%	0	0%	32,4734391	37,46101%	0,77364992	12,18346%	-55,543191	-12,1834%	Constant	Constant
13	Madrid, Community of (MD)	1	0	0%	0	0%	0	0%	0	0%	0	0%	Decreasing	Increasing
14	Murcia, Region of (MC)	0,98594618	0	0%	0	0%	0	0%	0,09710904	1,405341%	-30,609328	-6,68588%	Constant	Constant
15	Navarre, Community of (NC)	1	0	0%	0	0%	0	0%	0	0%	0	0%	Decreasing	Increasing
16	Basque Country (PV)	1	0	0%	0	0%	0	0%	0	0%	0	0%	Constant	Increasing
17	La Rioja (RI)	0,999447234	146,8260066	1,438457%	0	0%	5,33210028	4,841378%	0,00399193	0,055214%	-0,225122	-0,05521%	Decreasing	Constant

Source: Prepared by authors.

Annex II

TABLE 6.
Managerial efficiency levels, INPUT 1, 2 and 3 deviations, and OUTPUT 1 and 2 deviations with respect to managerial efficiency

Autonomous Community		Managerial Efficiency	I1 Deviations		I2 Deviations		I3 Deviations		O1 Deviations		O2 Deviations	
1	Andalusia (AN)	1	0	0%	0	0%	0	0%	0	0%	0	0%
2	Aragon (AR)	1	0	0%	0	0%	0	0%	0	0%	0	0%
3	Asturias, Principality of (AS)	0,955991995	-11,9621526	-0,749588%	-5,64204648	-20,6754%	0	0%	0,306727778	4,400685%	-57,3726696	-12,135943%
4	Balearic Islands (IB)	1	0	0%	0	0%	0	0%	0	0%	0	0%
5	Canary Islands (CN)	0,868406527	0	0%	0	0%	0	0%	1,121981323	18,730907%	-61,6749883	-13,159296%
6	Cantabria (CB)	1	0	0%	0	0%	0	0%	0	0%	0	0%
7	Castile and Leon (CL)	1	0	0%	0	0%	0	0%	0	0%	0	0%
8	Castile - La Mancha (CM)	1	0	0%	0	0%	0	0%	0	0%	0	0%
9	Catalonia (CT)	1	0	0%	0	0%	0	0%	0	0%	0	0%
10	Valencia, Community of (VC)	0,947534501	0	0%	0	0%	0	0%	0,336303846	5,24655%	-23,9499754	-5,24655%
11	Extremadura (EX)	0,890822407	-48,9951140	-3,076442%	-1,23428842	-5,272242%	0	0%	0,710744151	10,917729%	-51,7216488	-10,917729%
12	Galicia (GA)	0,894502012	0	0%	0	0%	0	0%	0,729906526	11,494591%	-48,0954356	-10,54979%
13	Madrid, Community of (MD)	1	0	0%	0	0%	0	0%	0	0%	0	0%
14	Murcia, Region of (MC)	0,947809905	0	0%	-7,42688383	-25,30910%	0	0%	0,360626751	5,218911%	-44,7816151	-9,781489%
15	Navarre, Community of (NC)	1	0	0%	0	0%	0	0%	0	0%	0	0%
16	Basque Country (PV)	0,957228529	-266,176902	-16,10626%	-3,19547227	-11,57825%	0	0%	0,293403015	4,277012%	-18,0164848	-4,277012%
17	La Rioja (RI)	1	0	0%	0	0%	0	0%	0	0%	0	0%

Source: Prepared by authors.