

Incorporating preference information in a range directional composite indicator: The case of Portuguese public hospitals

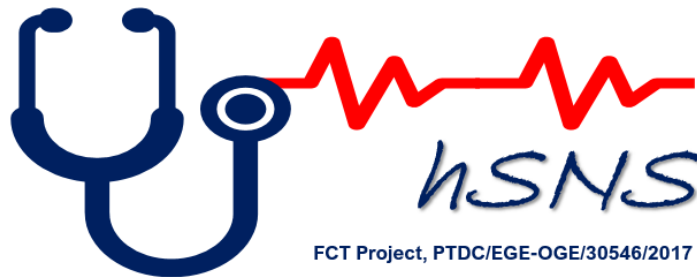
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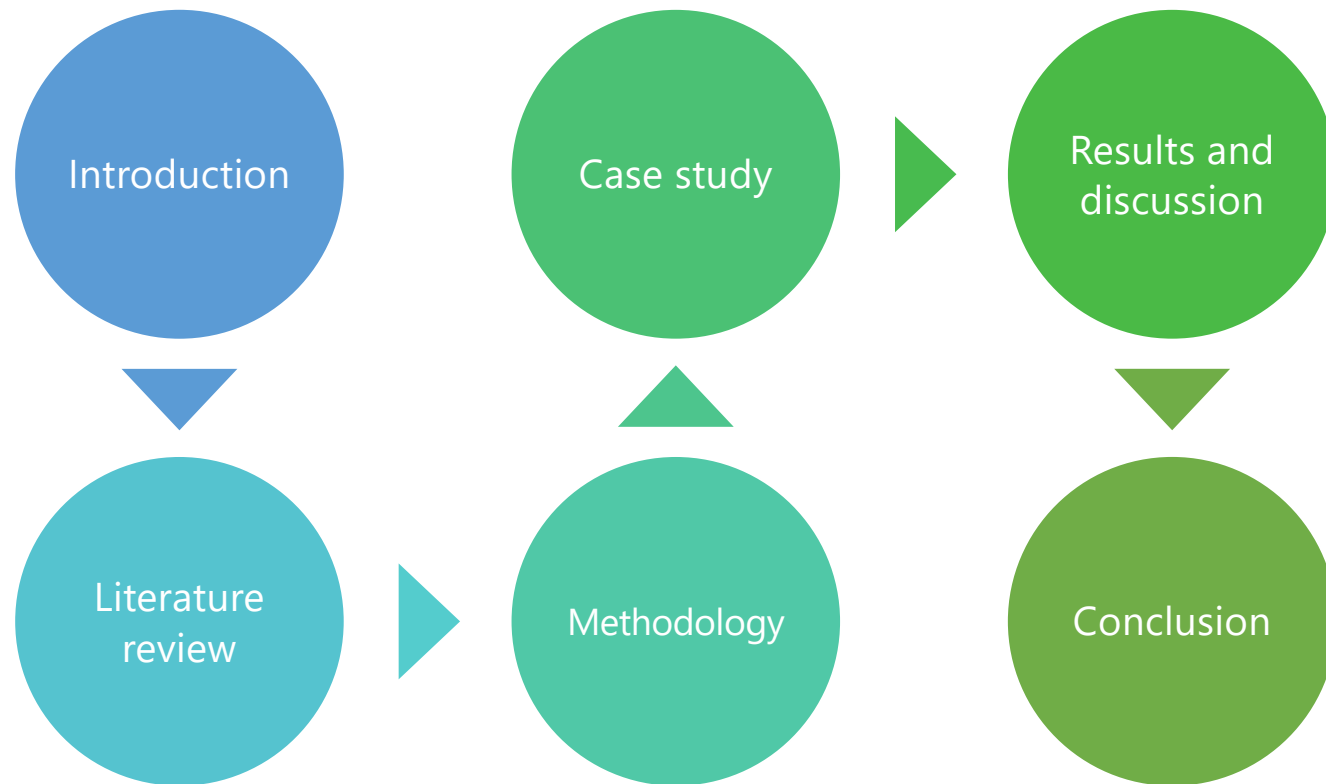
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INTRO- DUCTION

Composite indicators (CIs)

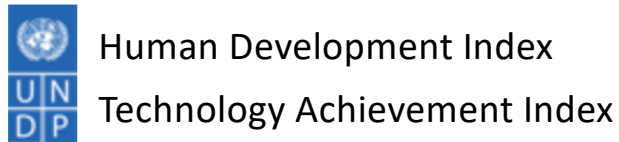
Advantages

- Summarise complex and multifaceted phenomena in the interest of contributing to decision-making
- Ease the interpretation and communication of information when compared to isolated or disaggregated pieces of data
- Allow a temporal assessment of the evolution of performance
- Facilitate the monitoring of the achieved results

Disadvantages

- If not properly constructed and interpreted, CI may lead to inaccurate or simplistic perceptions of reality

DEA-based CIs



Among the wide range of methodological approaches available for their construction (Nardo et al., 2008), Data Envelopment Analysis (DEA) emerges as a leading technique

In the last decade, DEA has gained increasing acceptance due to the popularisation of the 'Benefit-of-the-Doubt' (BoD) approach developed by Cherchye et al. (2007)

Morais and
Camanho
(2011)

D'Inverno et
al. (2018)

Oliveira et al.
(2019, 2020)

Silva et al.
(2020)

Healthcare: The most challenging sector with a need to improve its performance



The Portuguese National Health Service (SNS)

Founded in 1979, a few years after a post-dictatorial turmoil

Struggles to conform with the inherent features of a *Beveridge* model

Suffers from the alternation of conflicting political ideologies

Expends 9.1% of the country's GDP

Our contributions

Empirical

Collaborate with the Portuguese Ministry of Health to build a CI to evaluate the overall performance of Portuguese public hospitals

Generate a CI ranking of the Portuguese SNS's hospitals based on the aggregation of two perspectives ("sub-CIs")

- Users of the SNS
- Providers of the SNS

Methodological

Aggregation of two perspectives of performance represented by "sub-CIs"

Consider both desirable and undesirable outputs (Zanella et al., 2015)

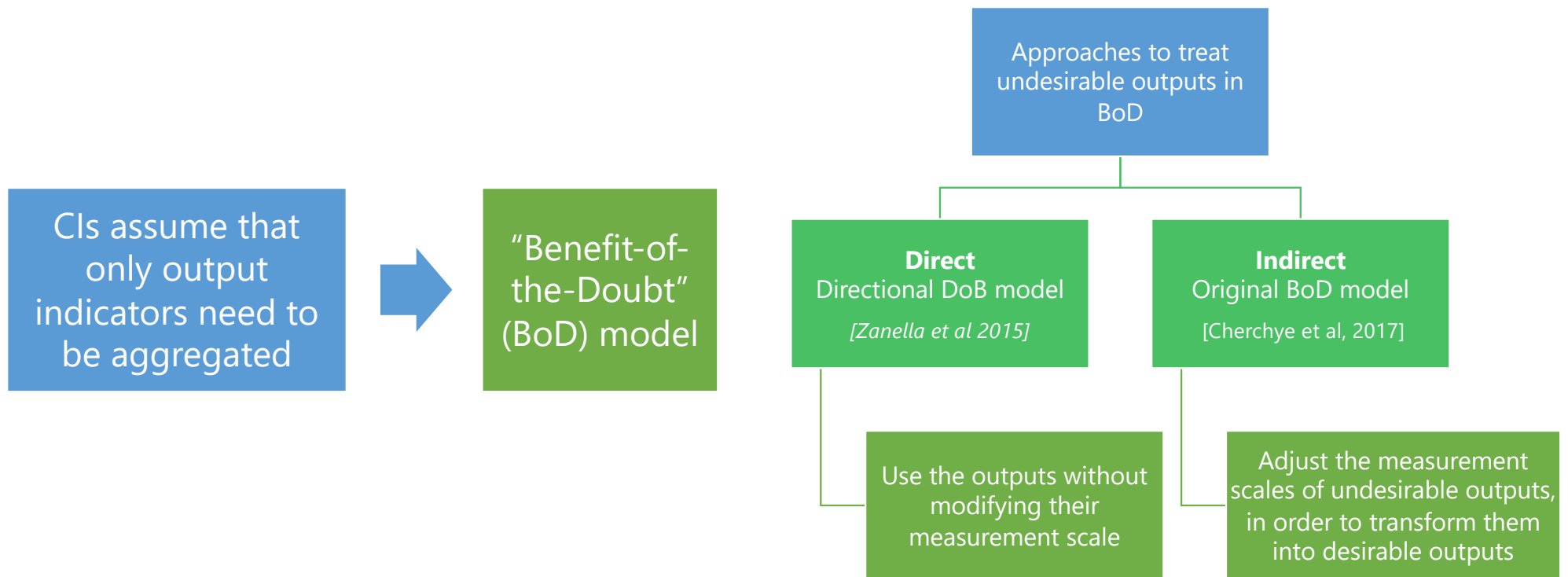
Incorporates preference information of decision makers

- The relative importance of indicators via weight restrictions (Zanella et al., 2015)
- Future achievements envisaged for each indicator via the identification of a Most Preferred Solution (Halme et al, 1999)

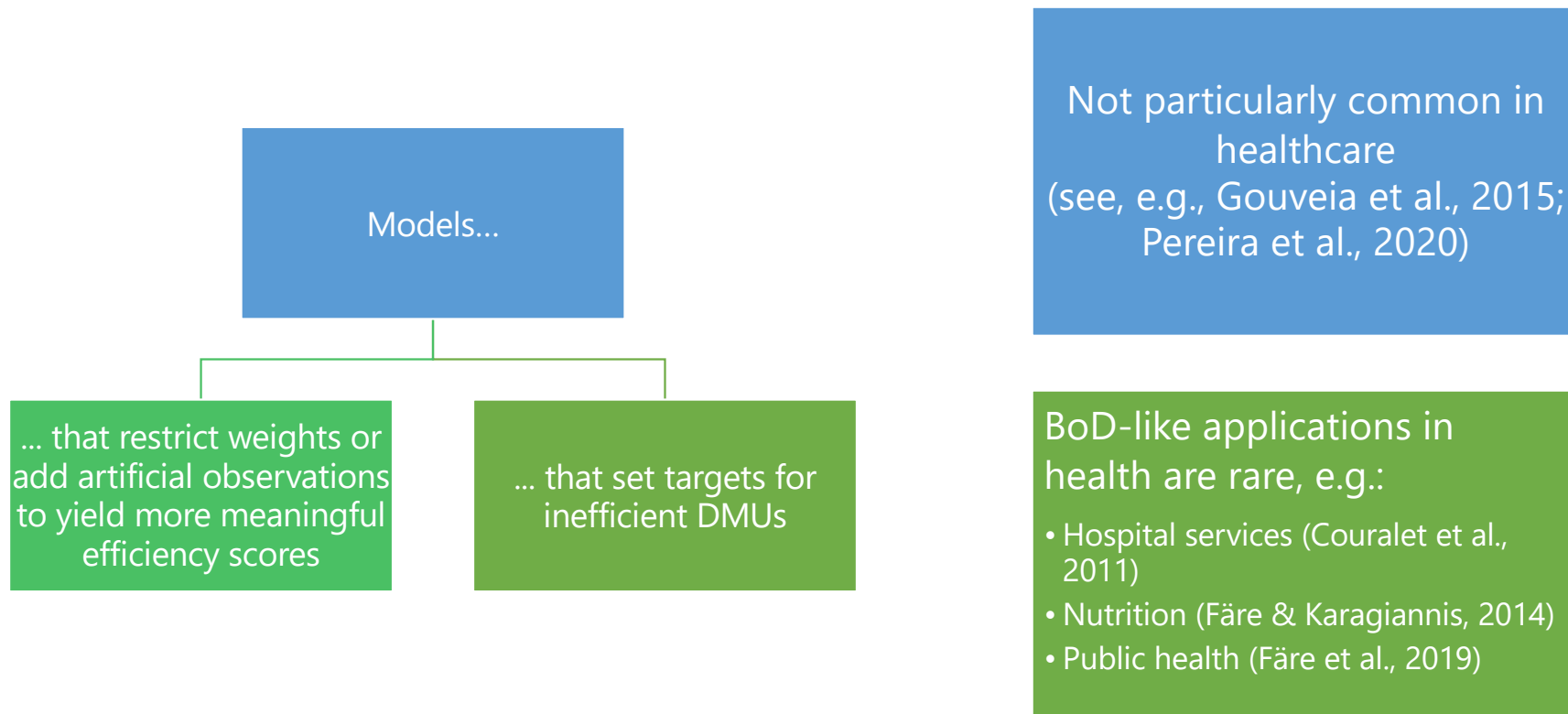
Use a range directional vector (Silva et al., 2019)

LITERATURE REVIEW

DEA vs. Desirable and undesirable outputs



Incorporating preference information in DEA



Reasoning



METH- ODOLOGY

Directional BoD CI model

The formulation of CIs specifies a **dummy input equal to one** for all DMUs

The Directional CI model assumes **constant returns-to-scale**

The resulting performance scores are equal regardless of the model orientation (we used **output orientation**)

The incorporation of preference information is done via **weight restrictions (primal formulation)**

The dual model (**envelopment formulation**) facilitates the estimation of **targets** pointing towards MPS

Model

$$\begin{aligned}
 & \max \quad \beta_{j_0} \\
 & \text{subject to} \quad \sum_{j=1}^n \lambda_j b_{kj} \leq b_{kj_0} + \beta_{j_0} g_b - \sum_{z=1}^{s+l+m} t_z d_{kz}^T, \quad k = 1, \dots, l \\
 & \quad \quad \quad \sum_{j=1}^n \lambda_j y_{rj} \geq y_{rj_0} + \beta_{j_0} g_y + \sum_{z=1}^{s+l+m} t_z c_{rz}^T, \quad r = 1, \dots, s \\
 & \quad \quad \quad \sum_{j=1}^n \lambda_j \leq 1 \\
 & \quad \quad \quad \beta_{j_0} \text{ is free} \\
 & \quad \quad \quad \lambda_j \geq 0, \quad j = 1, \dots, n, \\
 & \quad \quad \quad t_z \geq 0, \quad z = 1, \dots, (s + l + m),
 \end{aligned}$$

Range of possible improvement

$$(g_b, g_y) = (MPS_k - b_{kj_0}, MPS_r - y_{rj_0}).$$

AR- type I weight restrictions in the primal formulation

$$\frac{u_r \bar{y}_r}{\sum_{r=1}^s u_r \bar{y}_r + \sum_{k=1}^l p_k \bar{b}_k} \geq \phi_r, \quad r = 1, \dots, s,$$

$$\frac{p_k \bar{b}_k}{\sum_{r=1}^s u_r \bar{y}_r + \sum_{k=1}^l p_k \bar{b}_k} \geq \alpha_k, \quad k = 1, \dots, l,$$

$$\frac{\sum_{r \in q} u_r \bar{y}_r + \sum_{k \in q} p_k \bar{b}_k}{\sum_{r=1}^s u_r \bar{y}_r + \sum_{k=1}^l p_k \bar{b}_k} \geq \delta_q, \quad q = 1, \dots, m,$$

Estimations

Targets

$$b_{k0}^T = \sum_{j=1}^n \lambda_j^* b_{kj}, \quad k = 1, \dots, l$$

$$y_{r0}^T = \sum_{j=1}^n \lambda_j^* y_{rj}, \quad r = 1, \dots, s$$

Partial Efficiencies

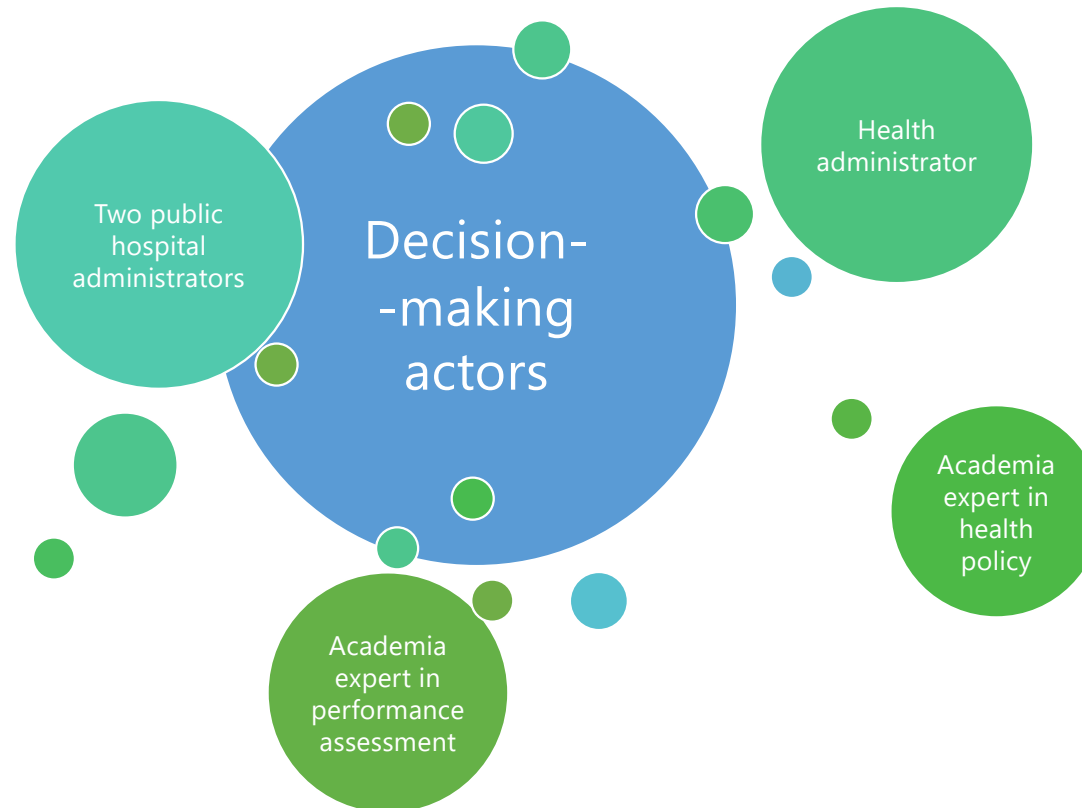
$$E_{y_{r0}} = \frac{y_{r0}}{y_{r0}^T}, \quad r = 1, \dots, s$$

$$E_{b_{k0}} = \frac{b_{k0}^T}{b_{k0}}, \quad k = 1, \dots, l$$

The CI is then obtained as the geometric mean of the partial efficiency scores for all indicators

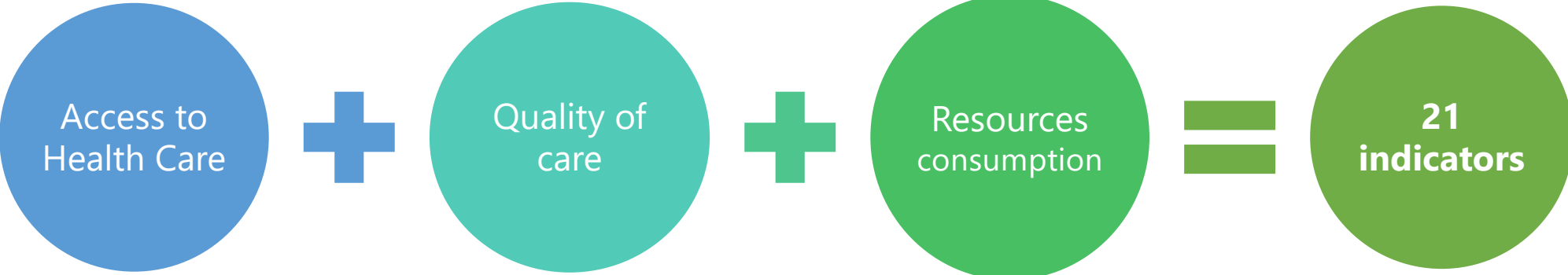
CASE STUDY

Stakeholders and their representatives



Data and sample: Indicators used

SNS Benchmarking Database, from Central Health System Administration (ACSS)



Data and sample: Assessment dimensions

| Dimension | Subdimension | Indicators | |
|-----------|------------------------|--------------------------------|----------------------------------|
| | | Users' perspective | Providers' perspective |
| Access | Services' timeliness | y_1, y_2, y_4 | b_{10} |
| | Services' availability | - | y_5, y_6, y_7 |
| Quality | Care appropriateness | y_3, b_1, b_2, b_3 | - |
| | Clinical safety | $b_4, b_5, b_6, b_7, b_8, b_9$ | - |
| Resources | Financial | - | $b_{11}, b_{12}, b_{13}, b_{14}$ |

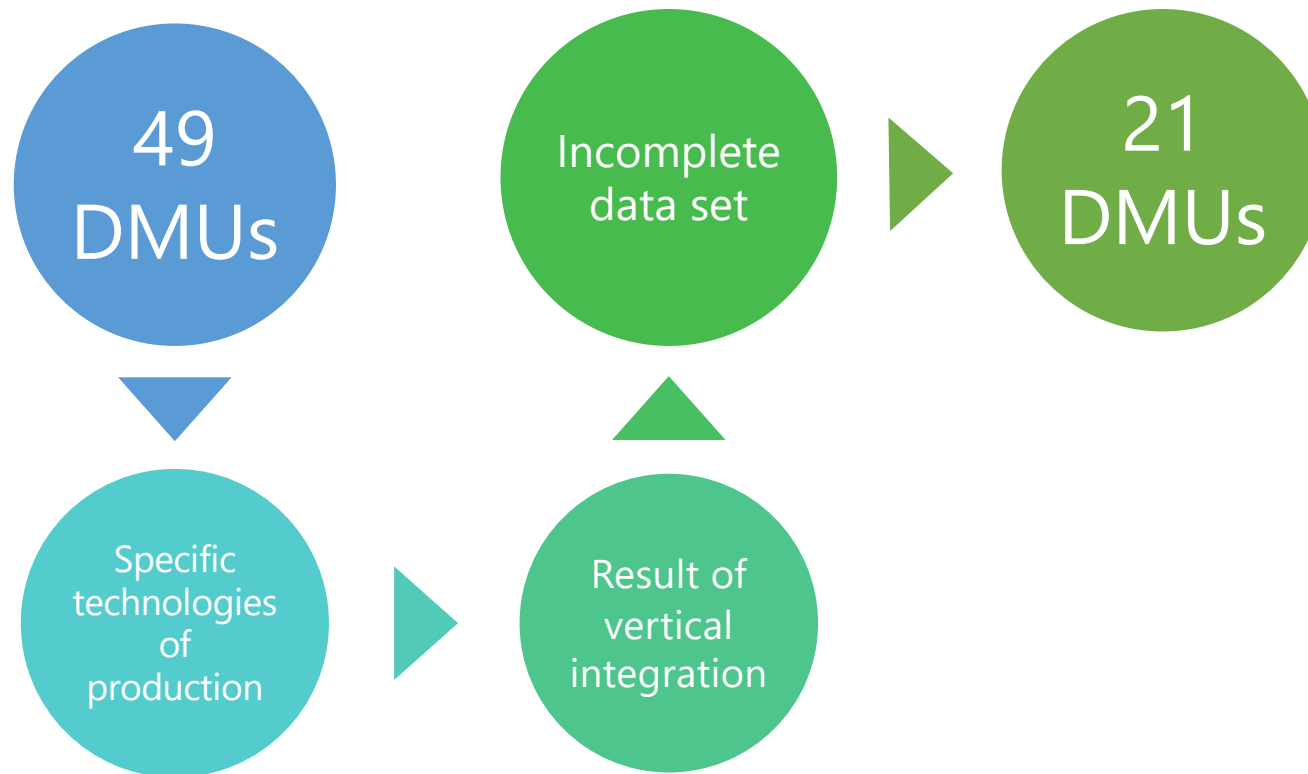
Data and sample: Users' perspective

| Output | Indicator |
|---------------------|--|
| y_1 (desirable) | <i>Number of non-urgent first medical appointments performed in adequate time per 100 first medical appointments within the maximum guaranteed response time (TMRG)</i> |
| y_2 (desirable) | <i>Number of users registered for surgical procedures within TMRG per 100 users registered within TMRG</i> |
| y_3 (desirable) | <i>Number of performed outpatient surgical procedures per 100 total outpatient surgical procedures</i> |
| y_4 (desirable) | <i>Number of users over sixty-five years old with surgically repaired hip fractures within 48 hours per 100 users over sixty-five years-old with surgically repaired hip fractures</i> |
| b_1 (undesirable) | <i>Number of readmissions within 30 days per 100 inpatients</i> |
| b_2 (undesirable) | <i>Number of inpatients with stays over thirty days per 100 inpatients</i> |
| b_3 (undesirable) | <i>Number of caesarean deliveries per 100 deliveries</i> |
| b_4 (undesirable) | <i>Number of pressure ulcer episodes per 100 episodes pertaining ulcers</i> |
| b_5 (undesirable) | <i>Number of bloodstream infections related to central venous catheter per 100 episodes pertaining bloodstream infections</i> |
| b_6 (undesirable) | <i>Number of pulmonary embolisms or post-operative deep vein thrombosis per 100,000 episodes pertaining possible pulmonary embolisms or post-operative deep vein thrombosis</i> |
| b_7 (undesirable) | <i>Number of post-operative sepsis episodes per 100,000 episodes pertaining possible post-operative sepsis</i> |
| b_8 (undesirable) | <i>Number of assisted vaginal deliveries with 3rd and 4th degree lacerations per 100 deliveries</i> |
| b_9 (undesirable) | <i>Number of non-assisted vaginal deliveries with 3rd and 4th degree lacerations per 100 deliveries</i> |

Data and sample: Providers' perspective

| Output | Indicator |
|------------------------|---|
| y_5 (desirable) | <i>Standard patient per full-time equivalent (FTE) physician</i> |
| y_6 (desirable) | <i>Standard patient per FTE nurse</i> |
| y_7 (desirable) | <i>Inpatient occupancy rate</i> |
| b_{10} (undesirable) | <i>Average delay before surgery</i> |
| b_{11} (undesirable) | <i>Adjusted staff costs per standard patient</i> |
| b_{12} (undesirable) | <i>Medication costs per standard patient</i> |
| b_{13} (undesirable) | <i>Clinical consumables' costs per standard patient</i> |
| b_{14} (undesirable) | <i>External supplies and services' costs per standard patient</i> |

Data and sample: DMUs



Application details

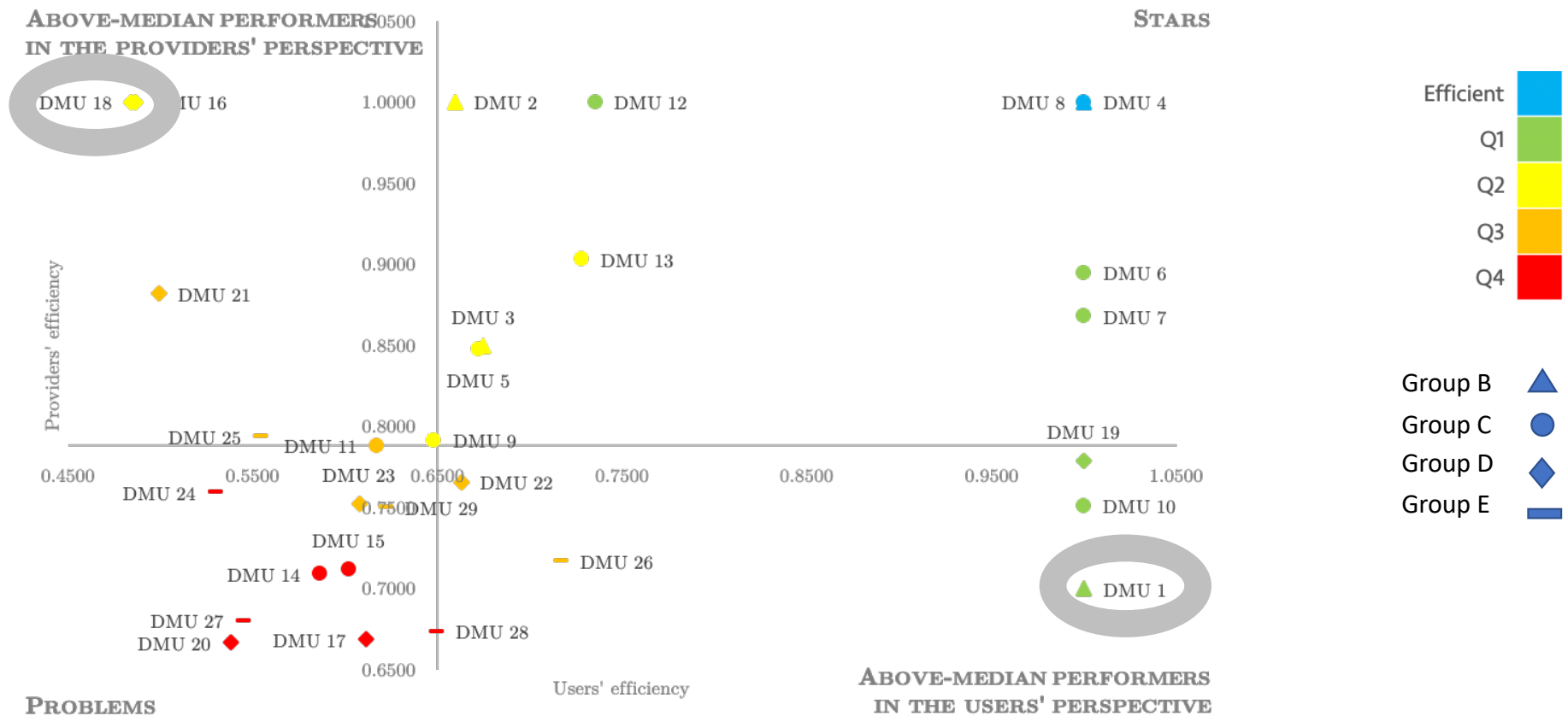


RESULTS AND DISCUSSION

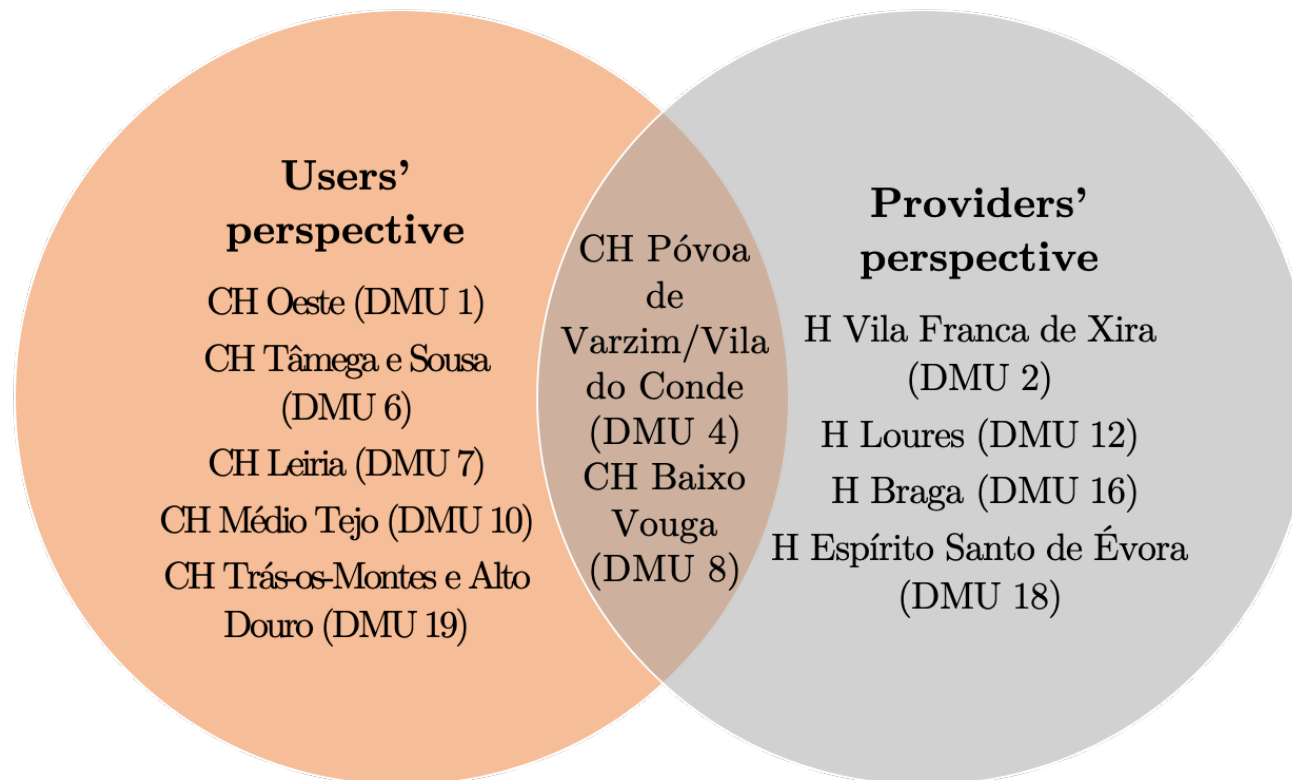
Descriptive statistics of CI results

| Perspective | CI average | Min. | Number of benchmark hospitals (CI=1) |
|--------------------|-------------------|-------------|---|
| Users' | 0.7046 | 0.4844 | 7 (in 29) |
| Providers' | 0.8172 | 0.6666 | 6 (in 29) |
| Aggregate | 0.7609 | 0.6023 | 2 (in 29) |

"Big picture"

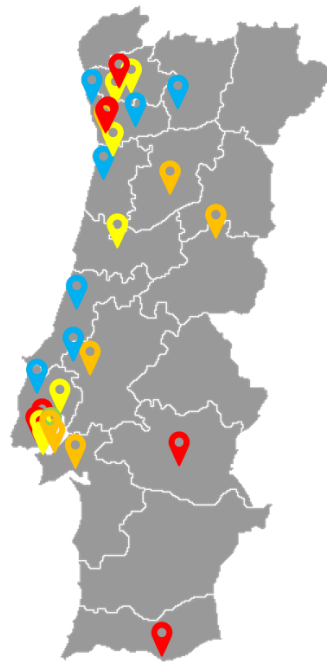


“Big picture”

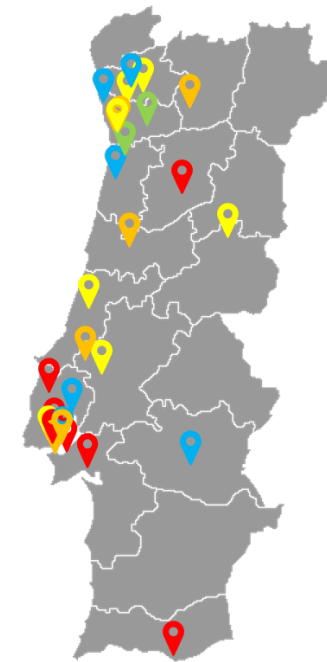
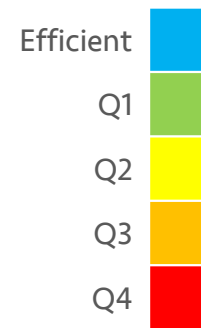


Geographical distribution

Users' providers



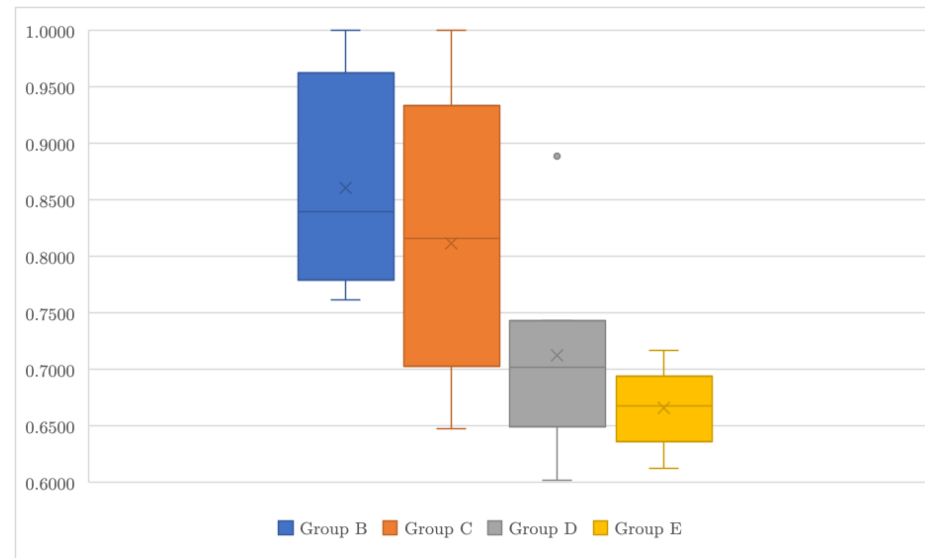
Providers' perspective



Comparison of hospitals in different groups: Kruskal-Wallis test

Are there differences among Hospital clusters' performance from the providers perspective or users' perspective?

The null hypothesis of identical distributions was rejected in the **users' perspective** ($p_value = 0,0195$) and not rejected in the providers' perspective ($p_value = 0,1708$)



| | | Group | | | |
|-------|---|-------|--------|--------|--------|
| | | B | C | D | E |
| Group | B | - | 0.5002 | 0.0401 | 0.0325 |
| | C | | - | 0.0245 | 0.0337 |
| | D | | | - | 0.4386 |
| | E | | | | - |

Comparison of Hospitals in different locations: Mann-Whitney U test

Are there differences between hospitals inland versus coastal areas, from the providers perspective or users' perspective?

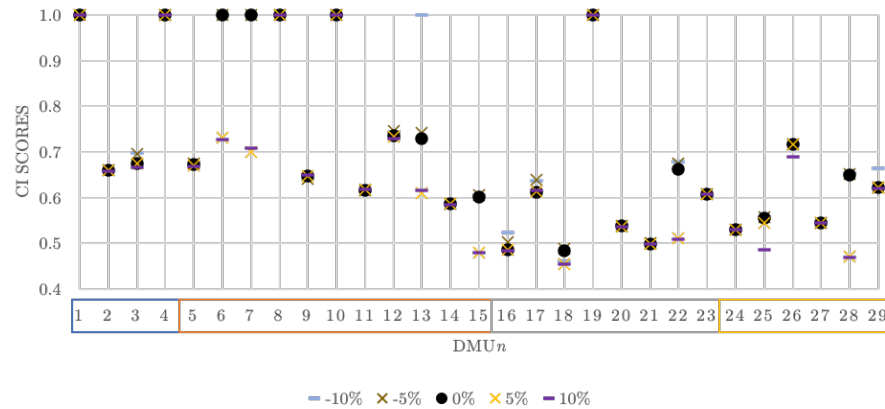
The null hypothesis cannot be rejected, meaning that the differences in performance between hospitals in coastal areas and in the interior of Portugal are not statistically significant (p-value of 0.6672 and 0.6037)

Desirable and undesirable Output Targets for DMU 20 (CH Universitário do Algarve, CI=0,6023)

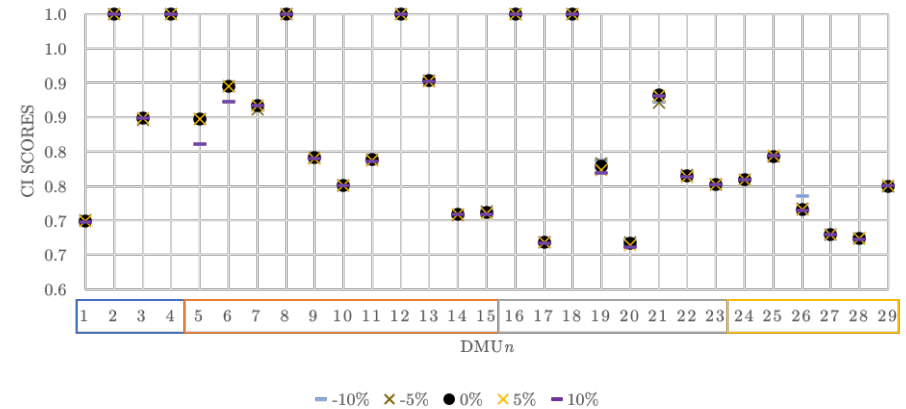
| Indicator | Description | Observed | Target | Partial Efficiency |
|------------------------|--|----------|----------|--------------------|
| y_5 (desirable) | Relates a standard patient with the number of weekly hours of physicians. | 63,63 | 69,21 | 92% |
| y_6 (desirable) | Associates a standard patient with the number of weekly hours of nurses. | 36,41 | 51,97 | 70% |
| y_7 (desirable) | Corresponds to the fraction between the number of inpatients and the number of inpatient beds. | 80,82 | 85% | 95% |
| b_{10} (undesirable) | Measures the number of days until a scheduled surgical procedure occurs among the total number of scheduled surgical episodes. | 1,38 | 0,45 | 33% |
| b_{11} (undesirable) | Looks at the relation between the adjusted amount (in €) paid to the staff and a standard patient. | 2252 € | 1760 € | 78% |
| b_{12} (undesirable) | Concerns the relation between amount (in €) spent in medication and a standard patient. | 789 € | 266,5 € | 34% |
| b_{13} (undesirable) | Checks the relation between the amount (in \euro) spent in clinical consumables and a standard patient. | 159 € | 145,88 € | 92% |
| b_{14} (undesirable) | Translates the relation between the amount (in €) spent in external supplies and services and a standard patient. | 653 € | 575,02 € | 88% |

Sensitivity analyses: variations in Weight Restrictions' bounds

Users' perspective

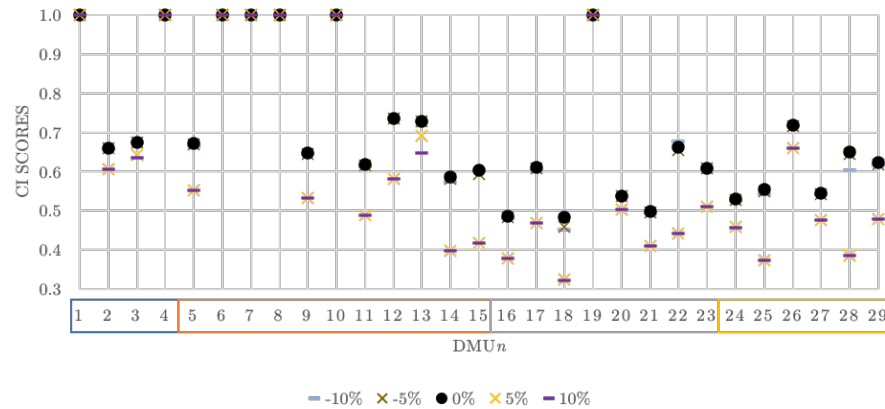


Providers' perspective

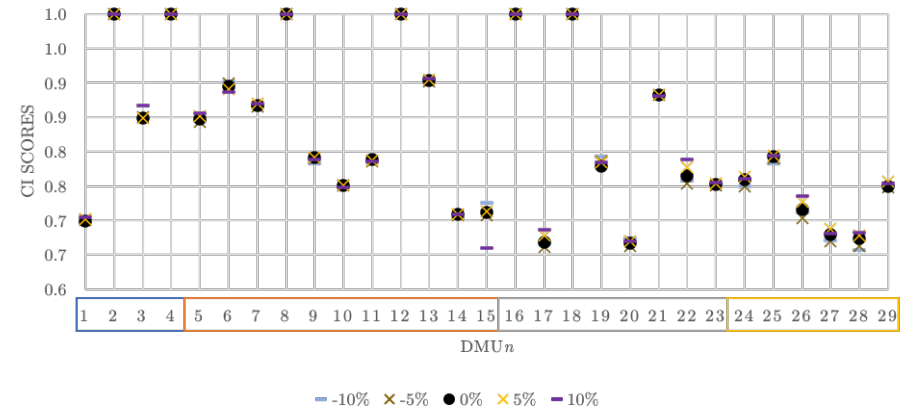


Sensitivity analyses: variations in Most Preferred Solution

Users' perspective



Providers' perspective



CONC- LUSION

Achievements

2 out of 29 DMUs were deemed efficient in the aggregate perspective

The persistent inefficiency of the institutions of Group E is worrying

The two assessed PPPs show an above-average performance in the providers' perspective

The lack of (efficient) public hospitals remains a pressing issue, not only in the Southern and Inland regions of Portugal, but also in the two major Portuguese cities - Lisbon and Porto

Limitations

Data availability

The elicitation process used may not have perfectly captured the decision-making actors' preference information

Future work

Use other MCDA approaches to incorporate the preference information of multiple DMs within DEA models

Assess the performance of the SNS's primary and secondary healthcare providers over time

hSNS project
(PTDC/EGE-OGE/30546/2017)

**AC-
KNOWL-
EDGE-
MENTS**

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Thank you for your attention!

