Economic and financial analysis of Portuguese public hospitals

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Abstract

Hospitals consume most of the health systems' financial resources. In Portugal, for instance, public hospitals represent more than 50% of the National Health Service (NHS) debt and are decisive in their financial insufficiency. Although profit is not the primary goal of hospitals, it is essential to guarantee their financial sustainability to ensure users' health care as well as the necessary resources. An analysis of the existing literature shows that researches focus mainly on the hospital's technical efficiency. Little or even no attention has been paid in the literature to the use of composite indicators in hospitals benchmarking studies. This study uses the Benefit of Doubt methodology alongside recent data about Portuguese public hospitals (2013-2017) to understand the factors that contribute to low performance and high indebtedness levels. Our economic and financial hospital performance analysis constructed indices for access, efficiency and productivity, financial, and quality dimensions. It demonstrated how hospitals' performance can be improved and that the financial dimension is an essential aspect for these entities.

Keywords: Public hospitals; Economic and financial indicators; Composite indicators; Performance; Benefit of Doubt.

1. Introduction

Over the years, ensuring the Portuguese National Health Service (NHS) financial sustainability has been one of the main challenges of successive governments (Simões et al., 2017). The NHS has been underfunded since 2010, due to the economic and financial crisis occurred in Portugal (Nunes and Ferreira, 2018). Nonetheless, in 2012 and 2013, the balance was positive, but there has been an increase in the NHS debt since then. In terms of the NHS, hospitals are the health care providers with the highest weight in debt, above 50%. This value has increased and reached 53.6% (provisional data) in 2017. More than 90% of NHS expenditure on hospitals is associated with public hospitals.[2] Moreover, it should be noted that hospital overdue payments represent a major expenditure source to NHS.[1]

Hospitals are health establishments with differentiated services whose primary goal is to "*deliver timely, equitable, patient-centered, safe, efficient, and effective secondary health care services that should be supported by evidence-based guidelines*" (Ferreira and Marques, 2019). Like other firms, public hospitals must be financially, socially, and environmentally sustainable. For instance, hospitals intend to improve patients' life quality, through the best services of assistance, with a minimum of waste (Ferreira and Marques, 2020). Profit

[1] See https://transparencia.sns.gov.pt/

is not the primary goal of public hospitals in Portugal. However, it is essential to guarantee their financial sustainability to ensure users' health care as well as the necessary resources.

Based on the hospitals' intent and their weight on the expenses, it is fundamental to analyze the Portuguese public hospitals' performance. Indeed, one must understand the factors contributing to the high levels of indebtedness as well as hospitals' performance levels.

Most hospital benchmarking studies use a nonparametric model, the Data Envelopment Analysis (DEA). It has essential advantages for the health unit comparison, such as the simplicity of the premises underlying the method and its ability to handle various inputs and outputs simultaneously (Carrilo and Jorge, 2017). An analysis of the existing literature shows that researchers focus mainly on hospitals' technical efficiency, where the use of various resources leads to the providing health care process (Patra and Ray, 2018). Regarding the use of input indicators, there is a high incidence in the ones referring to the available human resources and hospitals' capital. The economic variables that emerge focus primarily on hospital operating costs. There are also inpatient days as input (Fragkiadakis et al., 2016; O'Neill et al., 2008).

Concerning the outputs of healthcare provision, most articles focus on medical service indicators. The literature considers raw variables to characterize health care products, namely the number of inpatients, outpatients, emergencies, and surgeries, to name a few (Ferreira and Marques, 2019; Ferreira and Nunes, 2018; Fragkiadakis et al., 2016; Patra and Ray, 2018; Yildiz et al., 2018).

Just a handful of papers considered a benchmarking exercise with indicators to evaluate hospital performance. Karagiannis and Karagiannis (2018), for instance, used indicators as variables of the DEA model, focusing on three liquidity indicators. In other words, the authors constructed a CI using a DEA-like model just for evaluating the financial performance of hospitals in Greece. Meanwhile, Ferreira and Marques (2020) analyzed Portuguese public-private partnerships in health care, considering a few quality and access indicators, also through the construction of CIs. Still, those authors disregarded both the financial and the efficiency-productivity components. So far, and to the best of our knowledge, no study has considered a complete performance analysis, considering a broad spectrum of performance indicators, including efficiency and productivity, quality, access, and financial. There is, thus, a significant gap in the literature.

This research aims to analyze the overall performance of Portuguese public hospitals as measure by a global CI based on four other CIs (access, efficiency and productivity, financial, and quality). It was used the Benefit of Doubt (BoD) model, based on DEA. This performance appraisal approach does not focus on converting resources into products. Instead, it is a tool that aggregates several individual performance indicators into a single performance measure, with no explicit reference to the inputs (Cherchye et al., 2007). In this case, a linear programming tool optimizes weights or multipliers associated with indicators. The former allows the simultaneous reduction of the undesirable variables and increasing of the desirable ones, at different rates (Ferreira and Marques, 2020). This efficiency approach allows hospital classification and rankings construction.

This study appears as unique in hospitals comparison using CIs. No other case study on the Portuguese NHS has used such an approach. No other research has used financial, efficiency and productivity, quality, and access indicators simultaneously. Individual indicators aggregation in a summary performance measure facilitates the interpretation of the results. It provides an integrated and general view of hospital performance in the four categories and in general. The aim is to offer a new perspective of a benchmarking tool, using economic

and financial indicators. Besides, the intention is to identify the existence of trade-offs between four dimensions. It seeks to justify and counteract the public hospital entities' indebtedness level.

2. Case study: The Portuguese public hospitals

This section presents a case study to analyze Portuguese public hospitals' performance. The case study defines the methods, sample, and variables of the current research.

2.1. Models

The BoD is a form of constant returns to scale the original DEA model by Charnes et al. (1978). This approach does not consider the input side, which is a dummy variable equal to one for all observations, and outputs are the key performance indicators (Puyenbroeck, 2017).

BoD constructs a CI per hospital. The CI is equal to the maximum weighted arithmetic mean of the indicators considered, with endogenously determined multipliers. Multipliers are subject to a non-negative constraint to reflect that the CI is a non-decreasing function of the indicators. Additionally, the relative weighting is also subject to a normalization constraint. If any other assessed entity uses the same set of weights, the resulting value of the indicator is not higher than one (Karagiannis and Karagiannis, 2018).

Traditional models for the construction of CI assume that the higher the value of the indicator, the better the entity performance. Therefore, a hospital can improve its performance by increasing the value of its indicators. However, there are several real applications in which there are both desirable and undesirable indicators (Calabria et al., 2016). To aggregate both types of indicators, Zanella et al. (2015) proposed a model for the construction of CI derived from a Directional Distance Function (DDF) model of Chambers et al. (1996). The model avoids changing the magnitude of the undesirable output indicators. Eq. (1) details the models of Zanella et al. (2015).

$$\max \beta \tag{1}$$

$$s.t. \sum_{j=1}^{n} \lambda_j b_{kj} \leq b_{kj0} - \beta g_b, \quad k = 1, \dots, l$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rj0} + \beta g_y, \quad r = 1, \dots, s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, \quad j = 1, \dots, n.$$

In the Eq. presented, b_{kj} represents the indicators that should be minimized for each DMU j and y_{rj} represents those that should be maximized. The intensity variables are represented by λ_j. The vector g through its components $(-g_b, g_y)$ indicates each indicator direction (ascending and descending, respectively). The β factor designates the DMU inefficiency extent (Zanella et al., 2015). When the directional vector is specified as outputs current value for the DMU under evaluation, that is, $g = (-g_b, g_y) = (-b_{kj0}, +y_{rj0})$, the DDF is comparable to Shephard's output distance function and, as such, the expression $1/(1+\beta)$ gives the efficiency value. The results obtained correspond to CIs values which vary between zero and one, the latter being the value attributed to the best performance level observed in the sample (Calabria et al., 2016)

2.2. Data and sample

All required data for this research are available in the official databases: Portuguese Health Ministry, the Central Administration of Health Systems (*Adminstração Central do Sistema de Saúde, IP*),[2] in the Portuguese Health Ministry open data initiative, and from the reports and accounts provided per hospital.[3] Data collected from the re-

[2] BENCHMARKING ACSS: https://benchmarking-acss.min-saude.pt/
[3] TRANSPARÊNCIA SNS: https://www.sns.gov.pt/transparencia/

ports and accounts are in the balance sheets and income statements.

The current study focuses on the single hospitals and Hospitals Centers (HCs) belonging to the corporate public sector (EPE) to ensure the production process and structure homogeneity, and to ensure a fair comparison, avoiding biasing source (Ferreira et al., 2018a). Also, the substantial data absence for three HCs and two hospitals originates from their removal from the study. Because of that, the sample contains five single hospitals and 18 HCs, operating between 2013 and 2016 (four years). It results in a sample of 92 entries ((18+5)×4=92). In 2017, some original data from some entities are not available, which led to their suppression. Given the sensitivity of DEA to the sample size (Alirezaee et al., 1998), the year 2017 is analyzed in isolation, with 19 entries. The missing values only verified in 2016 and, for an entity, were replaced by the indicator's average value, considering the years when it was available (Zhu and Cook, 2007).

2.3. Variables

The choice of variables considered the following criteria: (a) a comprehensive literature revision, (b) availability and quality of the data for the sample and time interval considered, and (c) relevance for the study in question. The variables were clustered into four groups: access, efficiency and productivity, financial, and quality. One should avoid redundant information as well as an excessively high number of variables. They should be enough to explain hospital performance. In this way, it was analyzed the correlation between variables to verify the association between them and redundancy (Ferreira et al., 2019). Some variables exhibiting high correlation and causal relationships were removed. Thus, it is guarantee that each one of the remaining variables brings new and non-redundant information into the model.

A summary table (Table 1) identifies the 28 variables used in this case study and the direction that each should take. The desirable variables have an upward direction, that is, the higher the value, the better. In contrast, the undesirable variables have a decreasing direction, the lower the value, the better. Variables descriptive statistics are also presented.

The current ratio, operating margin, Return on Sales (ROS), and Solvability present a significant correlation. To avoid overlay, these were aggregated into two new variables via principal component analysis. The new variables, *(f12)* and *(f13)*, explain, at least, 95.98% of the original data variance, which means that they are good representations of hospitals' financial behavior. Eqs. (2) and (3) describe the variables (*f12*) and (*f13*), respectively.

$$f_{12} = 0.968\frac{solvability}{\sigma(solvability)} + 0.964\frac{current\ ratio}{\sigma(current\ ratio)} \quad (2)$$

$$f_{13} = 0.971\frac{ROS}{\sigma(ROS)} + 0.966\frac{operating\ margin}{\sigma(operating\ margin)} \quad (3)$$

It is considered the Return on Equity (ROE) and Return on Investment (ROI) indicators when analyzing and interpreting the entities' performance results, only. Although not consistently, some hospitals present negative values to all items from the balance sheet that make up these ratios, therefor these profitability ratios have positive values. This goes against entities technical bankruptcy situation and indicates a "false" better profitability situation than hospitals that are not in bankruptcy. Nevertheless, one should note that other indicators consider the financial items that make up ROE and ROI indicators, so they continue to be part of this analysis.

BoD does not accommodate negative indicators, which leads to a limitation regarding financial indicators (Karagiannis and Karagiannis, 2018). Several indicators have non-positive values, in any case. Thus, it was necessary to transform those with negative values, using data translation, by adding the absolute value of the observation with the most negative value. It is an

approach suggested by Zhu and Cook (2007) and applied by Zanella et al. (2013).

Also, basic DEA models (including BoD) require that the data is preferably positive. Thus, and as suggested by Bowlin (1998), the blank entries of the variables *(q1)*, *(q5)*, *(q6)* e *(q7)* were replace with a minimal positive value that does not exceed the minimum non-null value of the variable in question.

Data unavailability relating to variables (*q6*) and (*q7*) for the year 2017 leads them to be excluded from the analysis of the entities' performance that year.

Table 1 – Economic and financial variables: direction and basic statistics.

Group	Variable	Direction[a]	Average	Standard deviation	Min	Max
Access	*a1 Average length of stay*	↘	7.81	1.08	5.60	10.60
	a2 Hip fracture surgery in the first 48h	↗	45.49	20.70	4.99	93.75
	a3 Inpatient bed occupancy rate	↗	80.42	3.50	6.20	85.00
	a4 Rate of first medical appointments within time	↗	75.40	12.49	50.75	98.39
	a5 Rate of surgeries within time	↗	75.40	7.74	71.00	100.00
	a6 Standard patients per Full Time Equivalent doctor	↘	82.05	15.12	26.25	146.96
	a7 Standard patients per Full Time Equivalent nurse	↘	48.57	10.32	17.56	68.93
	a8 Waiting time before surgery	↘	0.95	0.29	0.44	1.63
Efficiency and productivity	*e1 Drugs expenses per standard patient*	↘	460.38	193.45	88.00	951.00
	e2 Operating expenses per standard patient	↘	2876.09	311.10	2389.00	3616.00
	e3 Personnel expenses per standard patient	↘	1551.47	264.05	1152.00	2241.00
	e4 Standard patient per expenses with supplies and external services	↗	0.00	0.00	0.00	0.00
	e5 Standard patients per Full Time Equivalent doctor	↗	82.05	15.12	26.25	146.96
	e6 Standard patients per Full Time Equivalent nurse	↗	48.57	10.32	17.56	69.93
Financial	*f1 Average payment period*	↘	231.35	159.81	0.64	599.00
	f2 Current liability ratio	↘	0.95	0.07	0.58	1.02
	f4 Equity ratio	↘	0.04	0.45	-2.02	0.74
	f5 Operating leverage	↘	-13.61	440.19	-3738.46	1714.05
	f7 Return on Assets	↗	-0.05	0.12	-0.72	0.21
	f12	↗	-3.26×10^{-7}	1.00	-1.27	3.38
	f13	↗	1.09×10^{-7}	1.00	-3.50	2.17
Quality	*q1 Caesarean section rate*	↘	26.71	9.11	0.00	40.00
	q2 Outpatient surgeries on potential outpatient procedures	↗	75.48	9.35	46.60	92.80
	q3 Rate of inpatients staying more than 30 days	↘	3.29	1.14	1.05	5.65
	q4 Rate of readmissions within 30 days after discharge	↘	8.86	1.66	3.55	12.12
	q5 Postoperative pulmonary embolism/ deep vein thrombosis rate	↘	0.19	0.13	0.00	0.58
	q6 Postoperative septicemia rate	↘	0.72	0.65	0.00	2.81
	q7 Trauma on vaginal delivery (instrumented and non-instrumented) with lacerations of 3rd and 4th degree	↘	2.60	1.95	0.00	8.67

[a] ↘ The lower, the better (detrimental). ↗ The higher, the better (auspicious).

2.4. Methodology specification

Through the exposed method in section 2.1., a CI per group was constructed, which subsequently allows the construction of an overall performance indicator. In that case, the BoD model to each group (partial CIs) was applied and the resulting outcomes as new observations for a final BoD model, which estimates the overall CI.

In the overall CI, limits on multipliers values were imposed to ensure that all indicators are accounted for in the performance evaluation (Calabria et al., 2016; Cherchye et al., 2007). To do so, the Assurance Regions type I (ARI) restriction was applied, proposed by Thompson et al. (1990). This type of constraint incorporates information about substitution marginal rates between inputs and outputs. The Eq. (4) restriction was added for each output.

$$L_{r,r+1} \leq \frac{u_r}{u_{r+1}} \leq U_{r,r+1} \quad r = 1, \dots, s \qquad (4)$$

The parameters *L* and *U* correspond to the upper and lower limits that the output multiplier (*u*) ratios can assume. It was decided to define the lower limit as 0.25 (*L*) and the upper limit as 0.75 (*U*).

Given the four indicators groups, one may formulate two distinct scenarios. Scenario I considers *Standard patients per FTE doctor* and *Standard patients per FTE nurse* in access. Scenario II assumes those variables in the efficiency and productivity group.

The methodology was based on annual frontiers (only the DMUs of the same year per analysis), and metafrontier (from a pooled sample considering all years). There is no evidence of frontier stability in time, and the results are dependent on the years. Thus, the results' exposition is direct to the ones obtained through annual frontiers.

It was used the MATLAB R2018a software to perform all computations. MATLAB is known for its high-performance proprieties, making it optimal for matrices manipulation and algorithms running.

3. Results and discussion

3.1. Period 2013 to 2016

Figure 1 provides the CIs' global average and benchmarks entities number per group of variables, both for Scenario I.

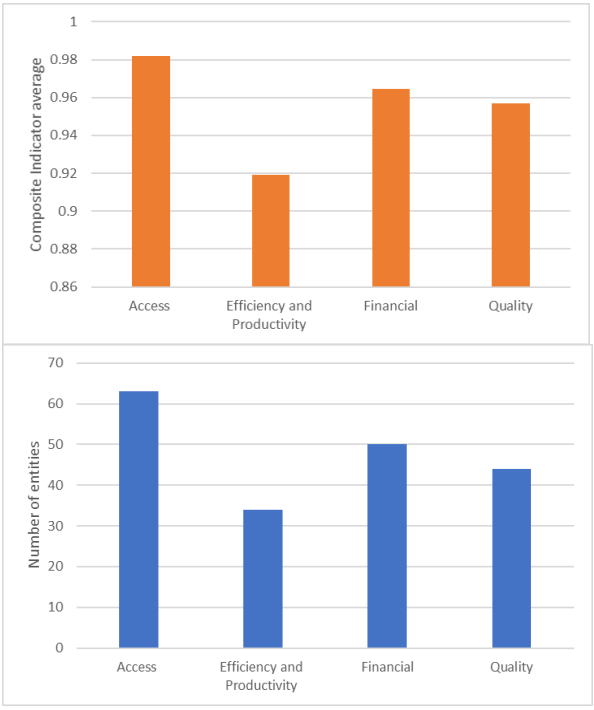

Figure 1 - Leading results per group (2013-2016): (a) CIs global average; (b) Benchmark entities number.

Given the study purpose, the first analysis comprises the four groups of performance comparison. Because of that, the Kruskal-Wallis test concluded that results show statistically significant differences among groups, rejecting the null hypothesis at the 5% significance level. This suggest that entities performance varies according with variables group and corroborates the notable differences in the averages CIs and in benchmark entities number.

Regarding the average entities' performance, it assumes high values in most groups. It is superior in the access group,. The categories in which the entities exhibit the worst average performance is efficiency and productivity group. These results suggest that hospitals perform worse than expected in their goods and resources consumption associated with the expenses of the hospital's production process. A high

number of expenses combined with inefficient management leads to poor hospital performance.

Another proper appreciation is based on the CI interval since they indicate the magnitude of the distance between the best and the worst performance for each of the perspectives (Calabria et al., 2016). It is verified that the difference in performance between entities is more noticeable in the quality group. On the other hand, it is found the smallest difference in the access group. It means that there are more discrepancies in terms of care appropriateness and clinical safety than in terms of resource exploration and care services provision.

It is interesting to note that findings regarding the entity performance vary according to each variables group. Furthermore, the possibility of the trade-off occurrence between the four dimensions is considered, in which an "optimum" value of CI in one implies the detriment of the entity performance in the others. Scatter plots between the four groups indicators under analysis with the identification of four quadrants from the averages of the indicators in question allowed to see a considerable number of entities are in the 2nd and 4th quadrants; that is, they present a "high" value in one dimension and "low" in the other.

Additionally, it is worth highlighting that, considering the entities to which the minimum CI values of each group corresponded, only two do not constitute benchmarks in the other groups. This means that, for example, the clinical safety of patients is compromised due to improving financial performance need, particularly regarding reducing debt and costs. In this sense, considerable efforts must be made to improve each dimension without sacrificing others.

Regarding the overall CIs, first it was allowed total flexibility in the multipliers' definition to allocate to indicators. It helps to define which entities have low performance, i.e., those that even with the option of "selecting" "optimal" multipliers are not considered benchmarks (Calabria et al., 2016). Overall, 16 "different" entities have been identified in this situation. For the set of entities that did not reach the best performance score, the information obtained through the identification of the benchmarks or best practices, as well as the performance in each group can be used to guide improvements. It is worth mentioning that most of the identified entities present a technical bankruptcy situation and that part of them were identified as less efficient in one of the groups. Thus, these can be the causes of the overall poor performance.

From a global performance perspective, entities have a relatively high average performance. Even so, the average inefficiencies' value corresponds to 498 thousand euros of current expenditure on hospital care. In total, it was identified nine "different" benchmark entities. This result does not seem to reflect the technical bankruptcy situation of three of the entities.

In line with the purpose and innovation of this study, an overall CI without the financial dimension was constructed to compare with the general CI obtained, including the four dimensions. The overall performance results, including or excluding the financial group, have different distributions, which leads to the Kruskal-Wallis test's null hypothesis rejection at a significance level of 5%. The inclusion of the financial group generally leads to a lower performance value and changes in the relative position that each entity occupies. As expected, the financial group harms the hospital's performance, given the indebtedness level that they present, which also has consequences on their liquidity, profitability, and structure. Although profit is not one of the hospital's goals, their financial situation has implications for users' health care provision. Findings suggest that new strategies should be adopted considering the financial dimension. It is an exciting category of variables for organizational performance. It offers new perspectives and a benchmarking tool for hospitals intending to maximize

their performance, which may complement the analyzes carried out before.

3.2. The year 2017

The analysis for 2017 does not include the same variables or the same entities as before. Although comparison with the remaining years is not possible, it is essential to note that the average performance in the financial and quality categories has decreased significantly. The same was true for overall performance. Hospitals' performance seems to be undermining, so analysis with more recent years would be interesting to verify this reality and prepare an intervention to reverse it. Nevertheless, average performance stays better in terms of access and quality instead of efficiency, productivity, and financial dimensions.

This year, the difference in performance between entities is more noticeable in the financial group. It means that there are more discrepancies in terms of liquidity, profitability, indebtedness, and hospital structure. This fact goes against the increase in expenses that the entities represent.

After all, the overall average performance is considerable (above 0.856). We identified just two hospitals as benchmarks.

3.3. Scenario I vs. Scenario II

The comparison between both scenarios assesses the impact of including variables *Standard patients per FTE doctor* and *Standard patients per FTE nurse* on the access or efficiency and productivity group, and consequently on the overall performance. The CIs do not depend on the group where these variables were included as estimates come from similar distributions. Complementarily, the Spearman correlation coefficient analysis indicates a results' positive association. It is an expected result as there was no change in values range, in CIs average values, nor on access and efficiency and productivity group CIs.

However, there is a change in hospitals' performance in the worst level of performance and the number of benchmarks per year. Even so, these changes are not significant enough. One could infer that the category where variables *Standard patients per FTE doctor* and *Standard patients per FTE nurse* were included has no significant impact on performance. Besides, since results considering variables are similar to those suppressing them, regardless of the group, those are non-determining variables for performance.

4. Summary, limitations, and future work

The present study analyzed Portuguese public hospitals' performance based on their economic and financial indicators. It becomes evident that overall performance should improve considerably. The financial dimension is a vital aspect for entities, even if their objective is not to generate profit. The most significant potential for improvement lies in this dimension, as well as on both efficiency and productivity. Health care providers must improve their performance in one dimension, which may imply the sacrifice of another. It means that there are potential trade-offs between the access, efficiency and productivity, financial, and quality groups, as they are somehow associated.

This study uses a beneficial tool for performance assessment when desirable and undesirable indicators are available, which facilitated the accommodation of the financial dimension. Besides that, the approach presented here allowed to rank the hospitals, aiming to motivate improvements in the hospital sector, and promoting a higher overall performance level achievement.

The intention was to contribute to benchmarking studies with innovative, more complete, and comprehensive research,

especially in the hospital sector. Nonetheless, the results presented here are not definitive. They must be compared with other studies constructed *a posteriori*, considering new and latest data (and, possibly, new groups of performance). Furthermore, new studies should accommodate the financial component, namely incorporating the ROE and ROI indicators. The inclusion of excluded entities, due to imperfect knowledge of data, would also be interesting to validate the exposed results.

In addition to the variables considered, there are external factors that affect hospital performance. Thus, it would be relevant to consider similar research that includes environmental variables as exogenous factors. Although there is no consensus on the best technique to use, we may recommend the order-m model.

Derived from the methodology used, one should note that the values of CIs depend on (a) the sample in question, (b) the variables chosen as indicators and, in the case of the overall CI, (c) the scheme and limit values imposed on the multipliers (Greco et al., 2019). Thus, any change in these aspects can lead to significantly different results from the ones presented in this study. Furthermore, the data processing carried out, although valid, can affect results.

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