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Public Hospital Mergers and Productivity: Evidence from the Portuguese NHS Using DEA-Malmquist Analysis

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Abstract: This study analyses the effects of public hospital mergers in Portugal, particularly the creation of hospital centres, on productivity levels. Grounded in the theoretical frameworks of New Public Management and Efficiency Theory, a Data Envelopment Analysis (DEA) approach, combined with the Malmquist Productivity Index, was used to evaluate performance. Results for the 2013–2015 period show that merged hospitals (hospital centres) generally had lower productivity levels than non-merged hospitals (hospital units), although the differences were not statistically significant. However, for hospitals merged in 2007, there is evidence of significant productivity gains in the post-merger period (2008–2014). These findings partially support the assumptions of New Public Management and Efficiency Theory concerning efficiency improvements through hospital mergers in the public sector.

Keywords: Data Envelopment Analysis (DEA); hospital mergers; Malmquist index; productivity; public hospitals

1. Introduction

Across many European Union (EU) countries, including Portugal, health expenditure has been rising faster than national economic output. In response, successive Portuguese governments have implemented a series of reforms aimed at enhancing the efficiency of the healthcare system, particularly within the hospital sector, which represents more than half of the total health expenditure. These reforms have been strongly influenced by the principles of New Public Management, which advocate for more business-like approaches in public services, such as decentralisation, performance measurement, and structural reorganisation. One of the most significant structural changes in the Portuguese National Health Service (SNS) was the creation of hospital centres—mergers of multiple hospital units under a single administration—intended to promote resource optimisation and improve service integration. These mergers, supported by Efficiency Theory, were justified by the expectation of economies of scale, increased productivity, and better use of human and financial resources. Despite the widespread adoption of these reforms, there remains a lack of empirical evidence on the actual productivity outcomes of hospital mergers in Portugal. Notably, Nunes [1], [2] investigated the impact of hospital mergers on productivity and found no consistent statistical evidence of performance improvement. These findings raise important questions about the effectiveness of hospital centres in achieving the intended outcomes of public sector reform. Notably, official evaluations and independent research on the impact of hospital centres on productivity have been scarce. In 2020, the Secretary of State for Health publicly

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acknowledged the need to assess the effectiveness of structural changes in public hospitals, highlighting the limited evidence of productivity gains from hospital mergers.

International literature presents mixed findings. Some studies suggest that mergers result in efficiency and productivity improvements, while others report neutral or even negative outcomes. In the Portuguese context, the few existing studies—namely those by Nunes [1], [2]—have yielded inconclusive results. While some productivity gains were observed, they were often not statistically significant. The limited scope of research assessing the impact of hospital mergers on productivity, both internationally and within Portugal, as previously is noteworthy [3], [4]. Given this context, this study seeks to address two central questions:

Q1: Do merged public hospitals in Portugal demonstrate higher productivity than non-merged hospitals?

Q2: Do merged hospitals experience productivity gains in the years following the merger?

To answer these questions, we examine the productivity of hospital centres and hospital units in the Portuguese NHS using Data Envelopment Analysis (DEA) methodology and the Malmquist Productivity Index. We test the following hypotheses:

H1: Merged public hospitals exhibit higher productivity than non-merged ones.

H2: Merged public hospitals achieve productivity gains in the post-merger period.

This article contributes to the existing literature by applying robust quantitative methods to a comprehensive sample of Portuguese hospitals, spanning different periods and sizes, and by incorporating both labour and capital inputs into the productivity analysis.

2. Mergers of Portuguese Public Hospitals

New Public Management advocates for the adoption of private sector practices in public administration, emphasising decentralisation, accountability, and performance metrics. In the context of healthcare, New Public Management has motivated structural reforms such as hospital mergers, which are expected to lead to improved efficiency, better resource management, and enhanced productivity of public services, including healthcare [5]. Efficiency Theory suggests that organisational changes, such as mergers, can generate synergies and economies of scale, ultimately resulting in productivity gains. In the hospital sector, these gains are often associated with the consolidation of services, reduction in duplication, better allocation of specialised resources, and more centralised decision-making processes.

Empirical research on hospital mergers has produced mixed results. Some studies report improvements in technical efficiency and cost-effectiveness following mergers. For instance, studies conducted in the United Kingdom and Scandinavia observed modest gains in performance indicators after structural consolidations. Notably, studies conducted by Coyne [6] and Levitz and Brooke [7] revealed statistically significant differences, indicating that merged hospitals exhibited higher levels of productivity than their non-merged counterparts. Conversely, other research has highlighted significant integration costs, loss of focus, and organisational complexity as barriers that undermine the expected gains from mergers. Also, Ferrier and Valdmanis [8] found that non-merged hospitals outperformed merged hospitals in the Malmquist Productivity Index, including its components: technical change and technical efficiency, with statistically significant differences favouring non-merged hospitals. The research by Ng et al. [9] revealed post-merger improvements in operational efficiency and care quality, with simultaneous decrease in productivity.

Similarly, a study in Portugal by Nunes [2] concluded that hospitals not involved in the merger process performed better compared to hospital centres (i.e., merged hospitals). Additional research by Gaynor et al. [10], Nunes [1], and Ng et al. [9] aimed to evaluate the post-merger productivity performance of Portuguese merged hospitals. Gaynor et al. [10] concluded that post-merger productivity improvements lacked statistical significance. Nunes [2] found that the policy of merging SNS hospitals didn't yield productivity gains in the medium term, with results even lower than the pre-merger period. However, Nunes [1] observed an approximate 29.3% increase in productivity between 2005 and 2012, albeit lower than before the merger.

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In addition to productivity outcomes, the literature also discusses the importance of time lags in assessing merger impacts. Several studies highlight that post-merger integration processes can take several years before potential efficiency gains materialise. This reinforces the need to distinguish between short-term disruptions and long-term outcomes in productivity analysis. Additionally, methodological approaches to measuring productivity are diverse. Among them, Data Envelopment Analysis (DEA) has been widely used due to its ability to handle multiple inputs and outputs without requiring price information. When combined with the Malmquist Productivity Index, DEA allows for the evaluation of productivity change over time, decomposing it into efficiency and technological change. This methodology is particularly suited to assessing the impact of structural changes like mergers in the hospital sector.

Vertical integration aims to ensure integrated healthcare delivery by managing various care levels—such as primary care, hospital care, and long-term care—and by coordinating all integrated elements into a network [11], [12], [13]. In the SNS, this integration is achieved through the establishment of Local Health Units (ULS) and the amalgamation of hospitals with health centres [13], [14], representing an innovative model for organizing primary and hospital healthcare services [13], [15]. It involves resource pooling, provision, and integrated management of healthcare, encompassing prevention, promotion, diagnosis, treatment, and rehabilitation of health conditions (Grone and Garcia-Barbero, 2001). Horizontal integration takes place when institutions providing similar services or close substitutes merge [11], [12], [16], [17], [18], [19], resulting in a single entity responsible for managing the merged organizations [17]. In Portugal, examples of such mergers include the establishment of hospital centres by integrating one or more hospitals [15] and the formation of Health Centre Groups (ACES) by merging one or more health centres [14].

Article 64 of the Constitution of the Portuguese Republic (CRP) mandates the realization of the right to health protection within the National Health Service (SNS) in accordance with the principle of universality, necessitating the coordination of various levels of healthcare [12]. Integration of healthcare was identified as a means to accomplish this coordination. The significance of the fundamental principle of universality was further emphasized in the Basic Health Law (Law no. 48, August 24, 1990), particularly in Base XXIV, which stipulates that the SNS must ensure the full provision of healthcare services [12]. Consequently, political decisions in Portugal have resulted in the implementation of diverse healthcare integration models, primarily manifesting as two forms of integration: vertical and horizontal integration [13], [14]. The integration of healthcare was formally incorporated into the Portuguese healthcare system with the enactment of Decree-Law (DL) 48357 on April 27, 1968, which approved the Hospital Statute. This decree provided for the establishment of hospital centres through the merger of hospital institutions under a unified administration, aimed at enhancing operational efficiency and achieving improved final outcomes.

Considering the theoretical underpinning of New Public Management and Efficiency Theory and the studies reviewed, we aim to test the following research hypotheses:

Hypothesis 1 (H.1): "Merged public hospitals demonstrate higher productivity than non-merged ones." Hypothesis 2 (H.2): "Merged public hospitals exhibit increased productivity gains post-merger."

Our research deviates from Nunes's studies [1], [2] in several aspects. Specifically, it compares the productivity of merged public hospitals with all non-merged public hospitals within the period under review. It expands the service portfolio assessed for productivity, incorporating sessions conducted in day hospitals and adjusting inpatient episodes to the MCI, reflecting the relative complexity of hospital caseloads. Additionally, it examines the productivity of merged and non-merged public hospitals, utilizing labour representative productive factors, namely, the number of doctors and nurses in FTE, an aspect yet to be explored within the context of Portuguese NHS hospitals.

Through testing hypotheses H.1 and H.2, our objective is to gauge changes in productivity and the breakdown of such changes within Portuguese public hospitals subjected to merger policies,

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comparing them with non-merged hospitals, i.e., hospital units. Furthermore, we seek to compare the productivity indices of merged public hospitals with that pre-merger.

By evaluating hypotheses H.1 and H.2, we aim to contribute toward answering the main research question, particularly addressing the specific research questions Q.1 and Q.2 outlined in the introduction.

3. Research Methodology

This study adopts a quantitative research approach, applying the Malmquist Productivity Index (MPI) through a panel data framework, using Data Envelopment Analysis (DEA). The chosen DEA model is the Charnes, Cooper, and Rhodes (CCR) input-oriented model, designed to evaluate the evolution of productivity in hospital centres and hospital units.

The MPI decomposes productivity change into two core components: technical change and technical efficiency. This methodology enables a comprehensive understanding of the drivers behind productivity dynamics in Portuguese public hospitals [8], [20], [21], [22].

Several software tools supported the implementation of this methodology: SPSS (version 25.0) for descriptive statistics, and Microsoft Excel (2016), complemented by DEA Frontier, ActionStat, and Analysis ToolPak, for MPI calculations using panel DEA.

3.1. Models and Samples

The study focuses exclusively on public hospitals within the Portuguese National Health Service (SNS), excluding Local Health Units (ULS), Public-Private Partnership (PPP) hospitals, and psychiatric hospitals. To ensure comparability among Decision-Making Units (DMUs), we adopted selection criteria based on Moreira [23], with adaptations. Hospitals were classified according to:

- Size, defined by the number of beds: Medium-sized hospitals: 90 to 650 beds; Large hospitals: more than 650 beds.
- Service portfolio, hospitals must include emergency care and at least one of the following services: day hospital or outpatient surgery, measured through Diagnosis Related Groups (DRGs).

Due to inconsistencies in hospital classifications during the study period, these criteria were chosen to ensure standardisation and inclusion reliability. The data were obtained from official sources including: Reports from Adminisração Central do Sistema de Saúde, IP (ACSS) (via SICA); ACSS website statistics; Internal data from Indice Case-Mix ICM (for 2007–2009).

Hypothesis H.1 was tested using hospital data from 2013–2015. From a population of 103 hospitals, a final sample of 81 observations (79%) was analysed. The sample was split into:

- Model A1: Medium-sized hospitals (n=58 observations)
- Model A2: Large hospitals (n=23 observations)

For H.1, the period of analysis was 2013–2015, due to the availability of ETC data.

Below, Tables 1 and 2 summarise the sample distribution.

Table 1. Model A1 - Medium hospitals with 90 to 650 beds: Sample for hypothesis H. 1.

REDUCED SAMPLE - MEDIUM SIZED HOSPITALS - [90 - 650] BEDS				
TYPE	YEAR			TOTAL
	2013	2014	2015	
Hospital Centre	14	15	15	44
Hospital Unit	5	4	5	14
TOTAL	18	18	19	58

Table 2. Model A2 - Large hospitals with more than 650 beds: Sample for hypothesis H. 1.

REDUCED SAMPLE - LARGE HOSPITALS - >650				
TYPE	YEAR			TOTAL
	2013	2014	2015	
Hospital Centre	7	6	5	18

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Hospital Unit	1	2	2	5
TOTAL	9	9	8	23

Hypothesis H.2 was tested on seven hospital centres created in 2007. Data were grouped into:

- Pre-merger period: 2005–2006 (aggregated 17 units)
- Merger year: 2007 (7 observations)
- Post-merger period: 2008–2014 (66 observations)

For H.2, the period was 2005–2014, to capture productivity before and after the creation of hospital centres.

Below, table 3 presents the sample structure.

Table 3. Model B - Hospital Centres merged in 2007: Sample for hypothesis H. 2.

REDUCED SAMPLE: HOSPITALS MERGED IN 2007 (PERIOD: PRE-MERGER/MERGER/POST-MERGER)											
TYPE	PRE-MERGER		YEAR MERGER	POST-FUSION							TOTAL
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Hospital Centre	7	7	7	7	7	7	6	6	6	6	66

3.2. Variables

To analyse H.1, labour inputs were used: number of full-time equivalent (FTE) doctors and nurses. For H.2, the number of inpatient beds was used, due to the unavailability of labour data. FTE values were adopted to mitigate distortions caused by part-time employment [24], [25].

Output variables reflect hospital service activity, aligning with prior empirical studies. These include: adjusted admissions, emergency episodes, outpatient consultations, day hospital sessions, medical DRGs, and surgical DRGs.

To ensure the validity of the variables within DEA-Malmquist models, Pearson correlation coefficients were calculated between each input and output. All models (A1, A2, B) showed positive and significant correlations, satisfying the isotonicity assumption required in DEA [26], [27], [28].

Tables **4 and 5** detail the variables and respective sources.

Table 4. Sources of Data Collection: *Inputs.*

HIP.	*INPUT*	*TITLE*	*DESCRIPTION*
H.2	*Beds*	*In-patient beds*	*No. of beds in the hospital's inpatient department*
H.1	*Doctors ETC*	*Full-time doctors*	*No. of full-time doctors*
H.1	*ETC Nurses*	*Full-time nurses*	*No. of full-time nurses*

Table 5. Sources of Data Collection: *Outputs.*

HIP.	*OUTPUT*	*TITLE*	*DESCRIPTION*
H.1/H.2	*Adjusted admissions*	*ICM-adjusted admissions*	*No. of patients treated in the hospital's inpatient unit adjusted by the MCI*
H.1/H.2	*Emergencies*	*Urgent services*	*No. of urgent consultations carried out in the emergency department*
H.1/H.2	*External consultations*	*External consultations*	*No. of outpatient consultations carried out*
H.1/H.2	*HDI sessions*	*Day hospital sessions*	*No. of sessions held in day hospitals*
H.1/H.2	*Medical centre*	*Outpatient episodes*	*No. of outpatient episodes classified under medical DRG*
H.1/H.2	*Outpatient surgery*	*Outpatient surgical episodes*	*No. of outpatient episodes classified under surgical DRG*

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This methodology enabled a robust comparative analysis of hospital productivity, isolating structural and temporal effects associated with hospital mergers in the SNS.

4. Results

4.1. DEA Panel Analysis Using the Malmquist Productivity Index

Below, we provide the Malmquist Productivity Index values for the examined hospitals, along with their detailed breakdown into components and sub-components. The data pertaining to Medium-Sized Hospitals and Large-Sized Hospitals, encompassed within Model A1 and Model A2 correspondingly, have been categorised according to the two types of hospitals under scrutiny: Hospital Units and Hospital Centres.

The Malmquist Productivity Index values for medium-sized hospitals, specifically medium-sized hospital centres (Table 6) and medium-sized hospital units (Table 7), are presented below:

Table 6. Malmquist Productivity Index: Model A1 - Medium-sized Hospital Centres (2013-2015).

DUM	*HOSPITAL*	*MALMQUIST PRODUCTIVITY INDEX*	*TECHNICAL CHANGE*	*TECHNICAL EFFICIENCY*	*PURE TECHNICAL EFFICIENCY*	*EFFICIENCY OF SCALE*
DMU_1	*Cova da Beira Hospital Centre, EPE*	*1,003*	*1,000*	*1,111*	*1,096*	*1,021*
DMU_2	*Entre o Douro e Vouga Hospital Centre, EPE*	*1,002*	*1,154*	*1,222*	*1,064*	*1,006*
DMU_3	*Setúbal Hospital Centre, EPE*	*1,001*	*1,068*	*1,000*	*1,037*	*1,066*
DMU_4	*Algarve Hospital Centre, EPE*	*1,001*	*1,000*	*1,000*	*1,000*	*0,913*
DMU_5	*Alto Ave Hospital Centre, EPE*	*0,883*	*0,825*	*0,816*	*0,881*	*0,880*
DMU_6	*Baixo Vouga Hospital Centre, EPE*	*0,827*	*0,781*	*0,786*	*0,825*	*0,817*
DMU_7	*Barreiro Montijo Hospital Centre, EPE*	*1,000*	*0,991*	*1,000*	*0,998*	*0,983*
DMU_8	*Médio Ave Hospital Centre, EPE*	*0,932*	*0,930*	*0,809*	*0,930*	*0,913*
DMU_9	*São João Hospital Centre, EPE*	*1,001*	*1,000*	*1,044*	*1,000*	*0,988*
DMU_10	*Leiria Pombal Hospital Centre, EPE*	*1,003*	*1,000*	*1,072*	*1,072*	*1,061*
DMU_11	*Médio Tejo Hospital Centre, EPE*	*1,004*	*1,000*	*1,091*	*1,110*	*1,009*
DMU_12	*Póvoa Varzim/Vila Conde Hospital Centre, EPE*	*1,004*	*1,180*	*1,096*	*1,083*	*1,000*
DMU_13	*Tâmega e Sousa Hospital Centre, EPE*	*1,003*	*1,102*	*1,000*	*1,078*	*1,084*
DMU_14	*Tondela Viseu Hospital Centre, EPE*	*1,001*	*1,013*	*1,000*	*1,000*	*1,009*
DMU_15	*Trás-os-Montes e Alto Douro Hospital Centre, EPE*	*1,002*	*1,000*	*1,000*	*1,000*	*0,980*
DMU_16	*Vila Nova de Gaia/Espinho Hospital Centre, EPE*	*1,001*	*1,000*	*1,000*	*1,000*	*0,951*
	AVERAGE	*0,979*	*1,002*	*1,003*	*1,011*	*0,980*
	MAXIMUM	*1,004*	*1,180*	*1,222*	*1,110*	*1,084*
	MINIMUM	*0,827*	*0,781*	*0,786*	*0,825*	*0,817*
	STANDARD DEVIATION	*0,052*	*0,102*	*0,116*	*0,079*	*0,071*

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Table 7. Malmquist Productivity Index: Model A1 - Medium-Sized Hospital Units (Period 2013-2015).

HOSPITAL UNITS						
DMU	***HOSPITAL***	***MALMQUIST PRODUCTIVITY INDEX***	***TECHNICAL CHANGE***	***TECHNICAL EFFICIENCY***	***PURE TECHNICAL EFFICIENCY***	*EFFICIENCY OF SCALE*
DMU_17	*Hospital da Senhora da Oliveira, Guimarães, EPE*	*1,003*	*1,000*	*1,000*	*1,000*	*1,041*
DMU_18	*Figueira da Foz District Hospital, EPE*	*1,006*	*1,000*	*1,000*	*1,000*	*1,000*
DMU_19	*Santarém District Hospital, EPE*	*1,003*	*1,000*	*1,000*	*1,000*	*0,979*
DMU_20	*Espírito Santo Évora Hospital, EPE*	*1,003*	*1,000*	*1,000*	*1,000*	*1,000*
DMU_21	*Garcia de Orta Hospital, EPE*	*1,002*	*1,000*	*1,000*	*1,000*	*0,913*
DMU_22	*Santa Maria Maior Hospital, EPE*	*1,009*	*1,000*	*1,000*	*1,000*	*1,013*
	AVERAGE	*1,004*	*1,000*	*1,000*	*1,000*	*0,991*
	MAXIMUM	*1,009*	*1,000*	*1,000*	*1,000*	*1,041*
	MINIMUM	*1,002*	*1,000*	*1,000*	*1,000*	*0,913*
	STANDARD DEVIATION	*0,002*	*0,000*	*0,000*	*0,000*	*0,043*

For the medium-sized hospital centres, the change in technical aspects is less pronounced compared to the variation in efficiency, signifying that the improvement in productivity is primarily attributed to the technical efficiency indicator. Within this group of hospitals, the breakdown of technical efficiency reveals an average increase in pure technical efficiency alongside a decline in scale efficiency. Notably, the scale efficiency index contributes the least to the total factor productivity of medium-sized hospital centres, as outlined above. Conversely, medium-sized hospital units sustain their modernisation capacity and technical efficiency on the efficiency frontier, with this indicator equalling the unit value. Similar to hospital centres, the Scale Efficiency Index is the least contributing factor to the total factor productivity of medium-sized hospital units.

Table 8 and table 9 present results for the Malmquist Productivity Index regarding Model A2, respectably for Large Hospital Centres and Large Hospital Units.

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Table 8. Malmquist Productivity Index: Model A2 - Large Hospital Centres (Period 2013-2015).

HOSPITAL CENTRES						
DMU	***HOSPITAL***	***MALMQUIST PRODUCTIVITY INDEX***	***TECHNICAL CHANGE***	***TECHNICAL EFFICIENCY***	***PURE TECHNICAL EFFICIENCY***	***EFFICIENCY OF SCALE***
DMU_23	*Central Lisbon Hospital Centre, EPE*	*0,910*	*0,953*	*0,829*	*0,953*	*0,946*
DMU_24	*Western Lisbon Hospital Centre, EPE*	*0,952*	*0,942*	*0,944*	*0,952*	*0,948*
DMU_26	*Porto Hospital Centre, EPE*	*1,001*	*1,000*	*1,060*	*1,031*	*1,013*
DMU_27	*São João Hospital Centre, EPE*	*1,000*	*1,035*	*1,045*	*1,006*	*1,009*
DMU_28	*University Hospital Centre of Coimbra, EPE*	*0,626*	*1,014*	*1,000*	*1,014*	*1,053*
DMU_29	*Lisbon North Hospital Centre, EPE*	*0,788*	*1,035*	*1,022*	*1,030*	*1,015*
DMU_30	*University Hospital Centre of the Algarve, EPE*	*0,860*	*1,001*	*1,000*	*1,024*	*1,015*
	AVERAGE	*0,877*	*0,997*	*0,986*	*1,001*	*1,000*
	MAXIMUM	*1,001*	*1,035*	*1,060*	*1,031*	*1,053*
	MINIMUM	*0,626*	*0,942*	*0,829*	*0,952*	*0,946*
	STANDARD DEVIATION	*0,116*	*0,037*	*0,078*	*0,034*	*0,039*

Table 9. Malmquist Productivity Index: Model A2 - Large Hospital Units (Period 2013-2015).

HOSPITAL UNITS						
DMU	***HOSPITAL***	***MALMQUIST PRODUCTIVITY INDEX***	***TECHNICAL CHANGE***	***TECHNICAL EFFICIENCY***	***PURE TECHNICAL EFFICIENCY***	***EFFICIENCY OF SCALE***
DMU_31	*Figueira da Foz Hospital, EPE*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
DMU_32	*Fernando Fonseca Hospital, EPE*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	AVERAGE	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	MAXIMUM	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	MINIMUM	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	STANDARD DEVIATION	*0*	*0*	*0*	*0*	*0*

The average Malmquist Productivity Index value for the large hospital centres in Model A2 stands at 0.877, lower than the observed value for both the group of medium-sized hospital centres (0.979) and the group of large hospital units (1.000). Unlike medium-sized hospital centres, large hospital centres witnessed a greater variation in technical change compared to technical efficiency. This indicates that the progression in productivity is primarily attributed to technological advancements. The average Malmquist Productivity Index value for the large hospitals in Model A2 is 1, which is lower than the value for the medium-sized hospitals in Model A1 (1.004) and higher than that for the large hospital centres (0.877). On average, during the 2013-2015 period, all large hospital units demonstrated modernisation capacity and technical efficiency. However, in both scenarios, productivity remained constant at the unit level, showcasing stability in productivity levels.

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Model B incorporates data from hospital centres established in 2007, encompassing those with a bed capacity ranging between 90 and 650, within the 2005-2014 timeframe. This model serves the purpose of testing hypothesis H.2. It scrutinises the inputs: Number of Beds, and the outputs: Inpatient Admissions; Average Length of Stay; Urgent Care; Outpatient Consultations; and HDI Sessions. To compute the productivity of the hospital centres established in 2007 during the pre-merger phase (2005-2006), the inputs and outputs of the hospitals that later constituted the hospital centres under analysis were aggregated. This approach enabled the computation and presentation of the Malmquist Productivity Index concerning the hospital centres established in 2007 for the pre-merger duration spanning from 2005 to 2006.

Table 10. Malmquist Productivity Index of hospital centres created in 2007 (annual variation between two consecutive time periods *t* and *t+1*, from 2005 to 2014).

DMU	*2006/5*	*2007/6*	*2008/7*	*2009/8*	*2010/9*	*2011/10*	*2012/11*	*2013/12*	*2014/13*	*AVERAGE*
(DMU_1) Central Lisbon Hospital Centre, EPE	*0,8626*	*1,0007*	*1,0006*	*1,0006*	*1,0007*	*1,0006*	-	-	-	*0,9776*
(DMU_2) Alto Ave Hospital Centre, EPE	*1,0050*	*0,8792*	*0,8601*	*1,0262*	*1,0926*	*1,0732*	*1,0765*	*1,0432*	*1,0023*	*1,0065*
(DMU_3) Médio Ave Hospital Centre, EPE	*1,0029*	*1,0032*	*1,0033*	*1,0033*	*1,0035*	*1,0036*	*1,0296*	*1,0296*	*1,0036*	*1,0092*
(DMU_4) Porto Hospital Centre, EPE	*1,0012*	*1,0012*	*1,0746*	*1,0747*	*1,0013*	*1,0013*	*1,0014*	*1,0014*	*1,0014*	*1,0176*
(DMU_5) Tâmega e Sousa Hospital Centre, EPE	*1,0065*	*1,0022*	*1,0024*	*1,0023*	*1,0023*	*1,0023*	*1,0023*	*1,0023*	*1,0023*	*1,0028*
(DMU_6) Trás-os-Montes e Alto Douro Hospital Centre, EPE	*0,8881*	*1,0204*	*0,9959*	*0,9960*	*1,0326*	*1,3551*	*1,5988*	*1,3986*	*1,1888*	*1,1638*
(DMU_7) Vila Nova de Gaia/Espinho Hospital Centre, EPE	*1,0016*	*1,0017*	*1,0018*	*1,0019*	*1,0019*	*1,0019*	*1,0018*	*1,0019*	*1,0019*	*1,0018*
AVERAGE	*0,9669*	*0,9869*	*0,9912*	*1,0150*	*1,0192*	*1,0626*	*1,1184*	*1,0795*	*1,0334*	*1,0256*

According to the table provided, it's apparent that most hospital centres established in 2007 exhibited an upsurge in their productivity from 2009 onwards, marking the second year following the merger. Notably, the period between 2011 and 2012 evidenced the most substantial productivity spike, reaching 11.8 per cent. Conversely, the pre-merger duration spanning from 2005 to 2006 displayed the most significant decline in productivity, amounting to 3.3 per cent.

Compared with the pre-merger period, the hospital centres founded in 2007 exhibited an average productivity gain of 7.7 percent. Specifically, the post-merger period showcased the most notable surge in productivity, registering a growth of 4.5 percent.

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Table 11. Productivity of the Hospital Centres created in 2007: Before the merger, year of the merger and after the merger.

DMU	*HOSPITAL*	*BEFORE THE MERGER 2006-2005*	*FUSION YEAR 2007*	*AFTER THE MERGER 2008-2014*	*Δ I.MALM. AFTER MERGER/ BEFORE MERGER*
(DMU_1)	*Central Lisbon Hospital Centre, EPE*	*0,909*	*1,001*	*1,001*	*0,092*
(DMU_2)	*Alto Ave Hospital Centre, EPE*	*0,928*	*0,775*	*1,041*	*0,113*
(DMU_3)	*Médio Ave Hospital Centre, EPE*	*1,003*	*1,003*	*1,011*	*0,008*
(DMU_4)	*Porto Hospital Centre, EPE*	*1,001*	*1,001*	*1,022*	*0,021*
(DMU_5)	*Tâmega e Sousa Hospital Centre, EPE*	*1,005*	*1,002*	*1,002*	*-0,003*
(DMU_6)	*Trás-os-Montes e Alto Douro Hospital Centre, EPE*	*0,926*	*1,001*	*1,233*	*0,307*
(DMU_7)	*Vila Nova de Gaia/Espinho Hospital Centre, EPE*	*1,002*	*1,002*	*1,002*	*0,000*
	AVERAGE	*0,968*	*0,969*	*1,045*	*0,077*

In summary, it's evident that, on average, the hospital centres established in 2007 enhanced their productivity during the post-merger period. This increase was more pronounced in the post-merger phase (4.5%) compared to the pre-merger period (-3.1%).

4.2. Testing the Research Hypotheses and Interpreting the Results

4.2.1. Test of Hypothesis H. 1

To test Hypothesis H.1: "Merged public hospitals exhibit higher productivity than non-merged ones." Using Models A1 and A2, we compared the Malmquist Productivity Index (MPI) and its components—Technical Change, Technical Efficiency, Pure Technical Efficiency, and Scale Efficiency—between merged and non-merged hospitals for the 2013–2015 period.

Prior to selecting the appropriate statistical tests, we verified the assumptions of normality and homogeneity of variances. The Shapiro–Wilk test was applied to assess data distribution, and Levene's test was used to test variance homogeneity. Depending on the results, either the parametric Student's t-test or the non-parametric Mann–Whitney U test was employed to assess differences between the two groups.

Model A1: Medium-Sized Hospitals (90–650 beds)

Model A1 includes both hospital centres and hospital units, using inputs such as the number of full-time equivalent (FTE) doctors and nurses.

The Shapiro–Wilk test confirmed that the Scale Efficiency variable followed a normal distribution for both groups, allowing the use of the t-test.

For all other variables (MPI, Technical Change, Technical Efficiency, Pure Technical Efficiency), the Mann–Whitney U test was applied due to non-normality.

Table 12. Student's t-test and Mann-Whitney test - Model D1 - Hypothesis H. 1.

	Hospital Centres (Mean ± SD)	*Hospital Unit (Mean ± SD)*	*p-value*
Malmquist Index	*0,979*	*,052*	*,002*
Technical Change	*1,002*	*,102*	*,000*
Technical Efficiency	*1,003*	*,116*	*,000*
Pure Technical Efficiency	*1,011*	*,079*	*,000*
Efficiency Scale	*0,980*	*,071*	*,043*

Mann-Whitney test; statistically significant differences for $p < 0.05$.

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Scale efficiency: Shapiro-Wilk test indicates statistical significance for $p < 0.05$. Other indicators (Technical Change, Technical Efficiency, and Pure Technical Efficiency) were evaluated using the Mann-Whitney test. For these indicators, statistically significant differences were not observed for $p < 0.05$.

Regarding the additional indicators (Technical Change, Technical Efficiency, and Pure Technical Efficiency) displayed in the table, it is evident that the values were comparatively higher in medium-sized merged public hospitals, i.e., hospital centres comprising 90 to 650 beds, in contrast to non-merged public hospitals (hospital units). However, the observed disparities did not achieve statistical significance, considering the results at the 5% significance level.

Model A2: Large-Sized Hospitals (>650 beds)

Model A2 mirrors Model A1, except for including data from hospital centres and large hospital units with more than 650 beds.

To assess hypothesis H.1, we utilised the Malmquist Productivity Index and its components for hospital centres and units, as displayed in Tables 10 and 11.

Given the limited sample size of hospital units, we employed the non-parametric Mann-Whitney test for hypothesis H. 1.

Upon examination of the table below, it's noticeable that the average Malmquist Productivity Index and its components for large hospitals show higher values in non-merged hospitals compared to merged public hospitals. However, these disparities were not statistically significant ($p > 0.05$), preventing the rejection of H. 1.

Table 13. Mann-Whitney Test - Model A2 - Hypothesis H. 1.

	Hospital Centres (Mean ± SD)	*Hospital Unit (Mean ± SD)*	*p-value*
Malmquist Index	0.877 ± 0.116	1.000 ± 0.000	0.500
Technical Change	0.997 ± 0.037	1.000 ± 0.000	0.667
Technical Efficiency	0.986 ± 0.078	1.000 ± 0.000	0.889
Pure Technical Efficiency	1.001 ± 0.034	1.000 ± 0.000	0.500
Efficiency Scale	1.000 ± 0.039	1.000 ± 0.000	0.500

Mann-Whitney test; statistically significant differences for $p < 0.05$.

In summary, the research conducted between 2013 and 2015 on hospital centres and large NHS hospital units revealed that the average Malmquist Productivity Index of non-merged public hospitals (hospital units), along with the values computed for the indicators of Technical Change and Technical Efficiency, were higher than those obtained by merged public hospitals (hospital centres). However, as the p-value (0.500) exceeds the common significance level of 0.05 (or 5%), we conclude there isn't enough statistical evidence to reject Hypothesis H.1 when analysing the group of large public hospitals, contrasting the findings observed for medium-sized public hospitals.

Regarding the other indicators, Pure Technical Efficiency and Scale Efficiency, while the analysis demonstrates higher values in the large merged public hospitals (Hospital Centres), the p-value does not provide statistical evidence to suggest that these indicators for large merged public hospitals are superior to those of non-merged ones.

The outcomes of the hypothesis H.1 test, considering models A1 and A2, reinforce the conclusions drawn from a previous study conducted by Nunes [2] involving Portuguese public hospitals. That study concluded that the Malmquist Productivity Index of non-merged public hospitals surpassed that of merged public hospitals, albeit without reaching statistical significance.

4.2.2. Test of Hypothesis H. 2

The objective is to assess H.2: "Merged public hospitals achieve productivity gains after the merger compared to the period before the merger." To evaluate this, the Malmquist Productivity

Index of the hospital centres established in 2007 was analysed, both before (2005-2006) and after (2008-2014) the merger, integrated into Model B.

To select the appropriate statistical test for hypothesis H.2, we evaluated the assumptions for parametric tests: normality and variance homogeneity. The Shapiro-Wilk test revealed that the variables analysed lacked normal distribution ($p < 0.05$). Therefore, the Wilcoxon Mann-Whitney test was employed as an alternative to the Student's t-test for paired samples to test hypothesis H.2.

Upon examination of the subsequent table, the comparison between the Malmquist Productivity Index in the pre- and post-merger periods demonstrates a significant increase in the post-merger period. This confirms Hypothesis H.2 with a significance level of 5%, indicating that "Merged public hospitals achieve productivity gains after the merger compared to the pre-merger period."

Table 14. Shapiro-Wilk Test - Malmquist Productivity Index (Before and after merger) - Model B - Hypothesis H. 2.

Period	Mean MPI	Standard Deviation	p-value
Pre-merger (2005–2006)	0.96	0.04	
Post-merger (2008–2014)	1.04	0.08	0.046 *

Shapiro-Wilk test; statistically significant differences for $p < 0.05$: *$p < 0.05$.

The results show a statistically significant increase in productivity after the merger. This supports Hypothesis H.2, indicating that hospital mergers in 2007 were associated with long-term productivity gains. These findings are consistent with Nunes [1], who also observed improved productivity following hospital mergers, albeit without statistical confirmation at the time.

5. Discussion of Results

The findings of this study indicate that, between 2013 and 2015, both medium-sized and large non-merged public hospitals (hospital units) outperformed merged hospitals (hospital centres) in terms of the Malmquist Productivity Index. Despite this trend, the statistical evidence was insufficient to reject Hypothesis H.1, which posited that “the productivity of merged public hospitals is higher than that of non-merged ones.”

Several factors may explain the comparatively weaker performance of hospital centres. First, many of the centres analysed were recently established—namely in 2011, 2012, and 2013—which may have introduced transitional challenges not yet absorbed during the study period. The hospitals involved in these mergers often had limited service capacity or infrastructure, which may have hindered their ability to achieve productivity gains in the short term. Moreover, the early stages of integration may have triggered tensions between clinical staff and hospital management, contributing to inefficiencies and reduced performance during the initial post-merger years.

In medium-sized hospital centres, the results showed that productivity changes were primarily driven by gains in technical efficiency rather than by technological change. This contrasts with the results from large hospitals, where productivity growth was more strongly associated with technological advancements. This distinction likely reflects the greater complexity and technological requirements of large hospitals, which tend to manage more demanding clinical cases and therefore require substantial investment in infrastructure and innovation.

The analysis of hospital centres created in 2007, covering the 2005–2014 period, revealed a different pattern. From 2009 onwards—two years after the merger—most of these centres began to show clear productivity gains, with a particularly strong improvement observed between 2011 and 2012. A modest decline in productivity was identified between 2012 and 2014, which may be related to the post-crisis context in Portugal, where increased health expenditure was directed toward addressing accumulated deficiencies in hospital infrastructure and equipment after several years of austerity and underinvestment.

Importantly, the results confirm that the hospital centres created in 2007 recorded higher productivity in the post-merger period (2008–2014) compared to the pre-merger period (2005–2006).

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This provides statistically significant support for Hypothesis H.2, which asserts that "merged public hospitals achieve productivity gains after the merger compared to the pre-merger period." The evidence suggests that, over time, the integration process and restructuring efforts translated into improved resource use and performance.

In summary, while short-term productivity gains following mergers were not evident in recently created hospital centres, the medium- to long-term effects—as seen in the 2007 mergers—support the notion that hospital integration can enhance productivity when adequate time and resources are provided for post-merger consolidation. These findings offer partial support for public policies aimed at improving efficiency through hospital mergers in the Portuguese NHS, particularly when merger initiatives are strategically planned and supported by appropriate investment in people and technology.

6. Conclusions

Despite the widespread adoption of hospital mergers across health systems as a strategy to improve performance, the empirical evidence on their actual impact on productivity and efficiency remains mixed. Mergers are frequently justified through New Public Management principles and Efficiency Theory, which argue that integration can lead to gains via synergies, optimisation of resources, and economies of scale. However, both international and national studies have raised concerns about whether such restructuring efforts actually produce the expected improvements in performance, especially in complex systems like public healthcare.

This study aimed to evaluate the impact of hospital mergers on productivity, using the case of public hospitals in the Portuguese National Health Service (NHS) as the empirical setting. Specifically, it examined whether merged hospitals (hospital centres) outperform non-merged ones (hospital units) in terms of productivity, and whether mergers generate productivity gains over time.

To address these questions, a two-pronged methodological approach was adopted. First, data from 2013 to 2015 were used to compare the productivity of hospital centres and hospital units, using labour-related inputs such as the number of doctors and nurses in full-time equivalent contracts. Second, a longitudinal analysis of hospital centres created in 2007 was conducted, using data from 2005 to 2014 and focusing on capital inputs (number of inpatient beds).

The results showed that hospital units outperformed hospital centres in the 2013–2015 period, although the differences were not statistically significant. Therefore, there is insufficient evidence to reject the hypothesis that merged hospitals have higher productivity than non-merged ones. These findings align with previous studies suggesting that mergers do not automatically lead to productivity gains in the short term.

However, the longitudinal analysis of hospital centres created in 2007 showed significant productivity gains in the post-merger period compared to the pre-merger phase. This supports the hypothesis that hospital mergers may lead to improvements in productivity over time, provided that the merged entities are given sufficient time and resources to consolidate and adapt.

Taken together, the findings suggest that the assumptions of New Public Management and Efficiency Theory are only partially validated in this context. While short-term gains were not observed, the longer-term effects indicate potential benefits from merger-driven restructuring, particularly when supported by appropriate investment and governance mechanisms.

The study contributes to a better understanding of hospital productivity within the public sector and offers practical implications for health policymakers and hospital administrators. In particular, the results highlight the importance of considering both the timing and the conditions under which mergers are implemented, as these factors can significantly affect their outcomes.

This research also provides evidence relevant to ongoing policy discussions in Portugal, especially within the scope of the Recovery and Resilience Plan, which includes reforms in hospital governance. Although based on historical data, the findings remain pertinent for future decision-making regarding hospital integration and management models.

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Limitations of the study include the relatively small sample size, which required the use of non-parametric tests, and the restricted set of explanatory variables, which may not fully capture the complexity of hospital productivity dynamics. Nonetheless, by applying a robust methodological framework and focusing on comparable hospital groups, the study offers a solid empirical foundation.

Future research should explore the organisational and contextual factors that mediate the impact of mergers on productivity, as well as the interplay between efficiency and service quality. In particular, analysing the effects of vertical integration strategies, such as the creation of Local Health Units, could provide valuable insights into the evolving structure of public healthcare systems.

In summary, this study contributes to filling a notable gap in the literature on hospital performance and lays the groundwork for further research into the effectiveness of structural reforms in public healthcare.

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