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Performance and congestion analysis of the portuguese hospital services

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Abstract The health care services have been characterized by a growing demand by the citizens leading to the need of more and more resources. Population aging, new pathologies, drugs, as well as new treatments are some of the major factors for this. However, in hospitals, for example, consumption of a large number of inputs has not frequently corresponded to the production of the same or more proportion of outputs. Sometimes, the outputs even decline with the increase of inputs due to the influence of the congestion effect on efficiency. The heavy burden of the health sector on the state budget brings about the interest of research over its efficiency. This paper aims to assess the performance of the Portuguese hospitals and particularly the contribution of the congestion effect. We use the non-parametric technique of data envelopment analysis for this purpose and a double-bootstrap procedure to take into account the influence of operational environment on efficiency. Afterwards, by comparing three different approaches, we determine the importance of congestion in efficiency measurement and discuss its computation methodologically. The results suggest significant levels of inefficiency in 68 major Portuguese hospitals for the year 2005 and more than half of them were found to be congested.

Keywords Hospitals · Congestion · Efficiency · DEA · Portugal

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1 Introduction

Health protection is understood by the Portuguese citizens as a social and cultural right which implies a universal access with tendency to be free. It has been also constitutionally protected since 1976 and a National Health System (NHS) for this purpose was implemented in Portugal. This idea should support the need to establish priorities in the health sector determined by procedures based on equity and efficiency promotion through a proper management of financial, human and material resources (Schaffhauser-Linzatti et al. 2009). At the same time, the provision of this kind of public services should be carried out according to transparency and accountability criteria.

Unfortunately, the State management of public health services has proved to be frequently inefficient (HSJ 2009), unproductive, and even little transparent. The health sector in Portugal went through successive reforms over the past years carried out by the different governments (Barros 2004). Sometimes, within each government the policies change with the respective Ministry, bringing to light lack of coordination and strategy in this sector. However, a more customer-oriented service and the higher level of funding required (as well as its growing trend) require the adoption of managerial practices that lead to an efficient use of resources and to a quality of service improvement.

Comparing Portuguese health sector related expenses with other European Union (EU) and Organisation for economic Co-operation and Development (OECD) countries, there is evidence that they have grown at a rate higher than the economic growth (Rosa 2006). As a percentage of Gross Domestic Product (GDP), they represented in 2003 about 9.6% when in 1970 they only amounted to 2.6%. The expenses growth in the health sector is related to an unquestionable enhancement in the quality of service provided. Nevertheless, there are still important inefficiencies that need to be eliminated in order to improve the use of the scarce available resources. This aspect was emphasised by the Court of Auditors through an audit performed in 2003. It concluded that the waste of financial resources in the NHS reached 25% of the amount allocated to health sector (Nunes 2009). In monetary terms, in 2006, 25% of NHS expenditure planned corresponded to more than 2,000 million Euros.

There is a vast literature dedicated to the real spending on health, as well as its evolution which is heterogeneous among countries and over time. Among these factors (Thorpe 1995; Ferreira et al. 2006) are the economic growth (together with the positive elasticity of expenditure on the health sector compared to GDP), the speed of innovation and technological development in the fields of diagnosis and therapy (with increasing total costs and reduced marginal benefits results in the health sector), aging of the population (particularly the costs in the period prior to death), the intensity of work in health care delivery (and the fact that investment in the health sector does not replace work but rather demands it to be more qualified), and the Baumol effect (increasing relative prices in the health sector). The different organisational frameworks of the health care services and their financing may also be associated with a greater or lesser rate of change in health expenditure but with less explanatory importance.

In Portugal, the NHS is fundamentally based on a public management model. This system, operating for 30 years, can be congratulated for the harmony achieved between Portugal and other Europeans countries, regarding the outputs in the health sector. However, the evolution of society over time turned it into an obsolete, little responsive and disorganised system. Anyway, the programme of the current government (2005–2009), as the previous ones, gives priority to the financial sustainability of the NHS and to the improvement of the sector management.

The increasing demand requires policy guidelines focused on improving the relationship between costs and effectiveness, particularly, at the micro level. In this context, the present budget model is only possible if accompanied by the mechanisms of contracting and monitoring and if tools typical of private management are used in the pursuit of efficiency of the institutions included in the NHS (Giraldes 2003).

One of the major reforms in the NHS was the reorganisation and transformation of several hospitals (the larger ones), which were managed according to the public law and belonged to the administrative public sector (APS hospitals), in public companies managed in compliance with the commercial law. These hospitals (amounting to 31), currently called Public Enterprise Entity (EPE) Hospital, present more flexible and dynamic rules on management and, at least theoretically, they allow for an optimisation of services and resources. From the 84 hospitals that constitute the NHS universe in 2007, 31 are EPE Hospital (37% of the total), of which 21 are District Hospitals, 9 are Central Hospitals and the remainder is a local hospital. Central Hospitals cover an area wider than the District ones and usually encompass more areas of specialisation. Also recently other restructuring movement has led to several mergers and amalgamation of hospitals creating the so-called Hospital Centres (HC). Like this, from 2000 until 2007 the number of hospitals decreased from 221 to 84.

This paper intends to measure the efficiency of the Portuguese hospitals by means of the benchmarking non-parametric frontier technique of data envelopment analysis (DEA). Basically, this method, developed by Charnes et al. (1978) uses mathematical programming to build an efficient frontier (technology) represented by the efficient decision making units, in this case hospitals. This frontier enables us to measure the efficiency of each hospital, comparing it with the best practices. Contrarily to the parametric methods, like stochastic frontier analysis (SFA) which requires a specification of a functional form for the technology (e.g., translog), DEA lets data speak by themselves. Besides, it deals easily with multiple inputs and outputs, allows for the decomposition of efficiency, identifies best practices and the respective peers and is conservative (see about DEA technique and parametric techniques Fried et al. 2008).

Afterwards, the paper computes the congestion effect and its influence on the efficiency of the Portuguese hospitals. Sometimes, the increase of inputs (resources) over a given level (e.g., staff) can generate a decrease of outputs (e.g., patients or surgeries) produced, which represent a circumstance of congestion, in this case of inputs. Hospitals can be prone to the congestion phenomenon. Due to the fact that hospitals are characterized by a constant high level of demand by the population, we get the biased idea that more resources for the services are needed to support it. However, not always is this true. In this research different methodologies are applied in order to measure the congestion effect.

The contributions of this paper to the literature are twofold. Primarily, it measures the efficiency of Portuguese hospitals by non-parametric methods and determines the importance of congestion effect. It uses as well the recent double bootstrap procedure to investigate the influence of the operational and institutional environment on the efficiency of Portuguese hospitals (see Simar and Wilson 2007). This allows for the evaluation of the recent reforms implemented in the sector, namely whether they are being successful or not. As far as we know this is the first time that congestion is measured in the Portuguese hospitals and that the operational environment is accounted for. Secondly, the different techniques of measuring the congestion are compared. This is really new in the worldwide literature. Although some studies determine congestion in hospital service (see below), no one applies more than one technique. The remainder of this paper is organized in the following way. Section 2 presents the congestion concept and reviews the major studies found in the literature and Sect. 3 describes the different approaches available to measure the congestion. The results of DEA benchmarking technique for the Portuguese hospitals are shown and analyzed in Sect. 4. Section 5 displays and compares the congestion results obtained by different approaches. Finally, the main conclusions are drawn in Sect. 6.

2 The congestion effect

Hospitals, like other public services, have to set up their services (contract in advance for facilities, human resources, etc.) based on demand (of population) predictions. Unavoidably, they face the risk that the capacities of the inputs they contract for the future may be too small, resulting in bad quality of service, or too large, giving origin to inefficiency and sometimes congestion (Brailer 1992).

Since Johnson and Happ (1977) early study on this matter, concluding that "components in health delivery systems are particularly prone to congestion", the congestion effect and its implications have been considered a hot topic in the literature, being an object of study in many sectors, such as higher education (Flegg and Allen 2009), banks (Lotfi et al. 2007), tourism (Ma et al. 2008), transportation (Odeck 2006), and utilities (Marques and Silva 2006), among others. This issue has also been studied in the health sector. The majority of the authors measured congestion using a single approach. The objective of this study is a little different. In this paper, we will apply the three different approaches that were developed until now and we will analyze the similarities and differences among them, in order to conclude which hospitals are in fact congested.

The study of the congestion phenomenon, following a mathematical approach, was primarily published, after the work of Färe and Svensson (1980), by Byrnes et al. (1984), and Färe et al. (1985). Afterwards, Cooper et al. (1996) conceived another approach, which was later improved by Brockett et al. (1998) and Cooper et al. (2001a). Tone and Sahoo (2004) provided the last approach developed for this purpose. For ease of reference, the three procedures used to measure congestion (Färe et al. 1985; Cooper et al. 2001a; Tone and Sahoo 2004) will be quoted hereafter as FGL, CGL and TS approaches.

Despite the importance of this subject, there are some important aspects that remain without consensus, such as the congestion definition and its principles in each approach. These points were the basis of a debate in the literature promoted by Cherchye et al. (2001) and Cooper et al. (2001a,b) in which the merits and failures

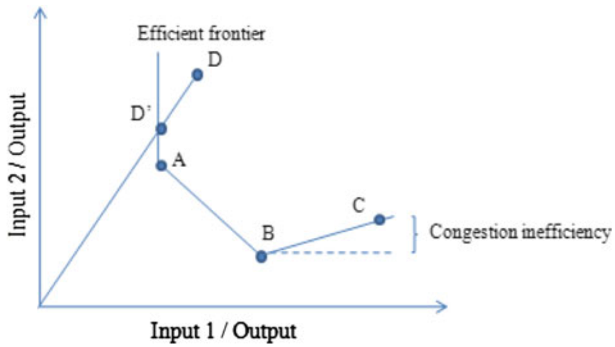

Fig. 1 DEA efficient frontier and congestion inefficiency

of the CGL and FGL approaches were discussed. This debate was inconclusive, however it helped us to realize why different outcomes (congestion results) are obtained through distinct approaches.

Congestion concept can be illustrated by Fig. 1 which represents the production technology of a hospital with two inputs and one output. In opposition to hospitals A and B, that are the efficient ones, and of hospital D, which is inefficient, it is easy to understand that hospital C reveals congestion signs, since more inputs lead to fewer outputs produced. Nevertheless, the degree of congestion varies with the approach used. The main difference among the three methodologies lies in the consideration of the slacks, which will be analyzed in detail in the next section.

In the health sector literature on performance, we identify several authors who focus their attention on this matter. In their research, the congestion phenomenon is analyzed in teaching hospitals (Grosskopf et al. 2001), in hospital uncompensated care (Valdmanis et al. 2004; Ferreira et al. 2006), in hospital mortality rates (Clement et al. 2008) and in hospitals, in general, (Valdmanis et al. 2008). A common point is that all the studies found in the literature applied only the FGL approach. Next, we will briefly review these major studies.

Grosskopf et al. (2001) used a DEA methodology to assess the relative technical efficiency of 213 teaching hospitals in the US. They applied the FGL approach, determining how much of the congestion inefficiency was due to excess use of residents and found that 20% of inefficiency was due to the congestion effect. The outputs considered were the inpatient surgeries, the outpatient surgeries, the outpatient visits, the emergency room visits, and the total number of inpatients admitted to the hospital. The inputs adopted were the physicians with staffing privileges, the medical residents/interns, the registered nurses, the licensed/vocational nurses, the other hospital personnel, and the number of licensed and staffed beds.

Valdmanis et al. (2004) assessed the capacity of 68 Thai public hospitals for the year 1999 to expand their services for the poor and the non-poor people. Using the FGL approach, congestion and capacity indices were estimated to measure poor/non-poor service trade-offs and capacity utilization. The study employed beds, doctors, nurses, and other staff, and the allowance expenditures, drug expenditures, and other operating expenditures as inputs. The outputs adopted were the outpatient visits for poor patients, the outpatient visits for non-poor patients, the inpatient cases adjusted with average diagnostic related group (DRG) weighting for poor patients, and inpatient cases adjusted with average DRG weighting for non-poor patients. Results of congestion found that the marginal product of poor and non-poor services are non-negative and that the financial incentives related to increased cost recovery from non-poor services did not affect the extension of services to the poor. This indicates that different patient types are considered as equals in a productive sense.

Ferrier et al. (2005) examined whether indigent care provided by 128 hospitals in the State of Oklahoma contributes to output congestion. Following FGL approach, the results indicated that hospitals differ in terms of technical efficiency due to the indigent care being delivered and that congestion has an important influence on it. The inputs adopted were the staffed and licensed beds, the physicians, the registered nurses, and the other hospital personnel. The outputs used were the inpatient privately paid days, the inpatient Medicare days, the inpatient Medicaid days, the inpatient charity care days, the inpatient bad debt days, and the number of outpatient visits.

Ferrier et al. (2006) measured how uncompensated care affects hospitals' ability to provide the services for which they do receive compensation. Applying output-based DEA for a sample of 170 Pennsylvania hospitals and based on FGL approach, the authors found that, on average, hospitals could have produced 7% more output if they had all operated on the best-practice frontier and that uncompensated care reduced the production of other hospital outputs by 2%. They found that congestion had a relevant role in hospital inefficiency. Beds, registered nurses, licensed practical nurses, residents, and other labour were the inputs considered whereas inpatient surgeries, outpatient surgeries, emergency visits, non-emergency outpatient visits, adjusted inpatient days, and uncompensated care were the outputs adopted.

Clement et al. (2008) considered undesirable variables and congestion (according to the FGL approach) to investigate performance and quality of care in US hospitals. Using a data set of hospitals from 10 US states (667 hospitals for the year 2000), they jointly evaluated desirable hospital patient care output (e.g., patient stays) and the simultaneous undesirable output (e.g., risk-adjusted patient mortality) that occurs. The inputs adopted comprised the registered nurses, the licensed practical nurses, the other personnel, and the staffed beds. As outputs, the births, the outpatient surgeries, the emergency room visits, the outpatient visits, and the case mix adjusted admissions were utilized. The results emphasized important signs of congestion in hospitals and showed that lower technical efficiency was associated with poorer risk-adjusted quality outcomes.

Using FGL approach, Valdmanis et al. (2008) analyzed the congestion to assess the trade-offs between quality and efficiency in 1,377 urban US hospitals of 34 states operating for the year 2004. The model specification encompassed the bassinets, the acute beds, the licensed and staffed "other" beds, the resident nurses, the licensed practical nurses, the medical residents, and the other personnel as inputs and as outputs the Medicare case-mix index adjusted admissions, the surgeries, the outpatient visits, the births, and the other patient days. The authors found that inefficiency and quality congestion are associated with some hospital characteristics. Relevant inefficiencies were discovered (outputs could be increased by 26%) from which about 3% were attributed to quality congestion.

In sum, the literature on congestion of health services proves the importance of this phenomenon in the efficiency. Although the studies most of the times employ the same technique (FGL approach), the results are unequivocal about its relevance. This paper innovates by applying different approaches to compute the congestion, comparing the results between them.

3 Efficiency and congestion measurement methods

3.1 DEA

This paper uses the non-parametric frontier method of DEA to evaluate the performance of Portuguese hospitals. Using DEA, the technical efficiency of each hospital is obtained through the comparison (by distance) with an efficient frontier formed by the hospital best practices. The process of measuring the efficiency of n hospitals corresponds to the resolution of a set of n linear programming algorithms. The following algorithm due to Charnes et al. (1978) describes an input-oriented model which considers constant returns to scale (CRS) and strong disposability of inputs:

$$\begin{aligned} \theta^*_{CRS} &= \min \theta \\ \text{s.t.} \quad & \sum_{j=1}^{n} x_{ij}\lambda_j - \theta x_{io} \geq 0 \qquad i = 1, 2, \ldots, m, \\ & y_{ro} - \sum_{j=1}^{n} y_{rj}\lambda_j \geq 0 \qquad r = 1, 2, \ldots, s, \\ & \lambda_j \geq 0 \qquad j = 1, 2, \ldots, n. \end{aligned} \tag{1}$$

In this model, known as CCR-DEA or simply CRS, the j index corresponds to the number of hospitals, x_{ij} are the amount observed of input $i = 1, 2, \ldots, m$ used by hospital_j, y_{rj} concerns the amount observed of output $r = 1, 2, \ldots, s$ yielded by hospital_j, x_{io} correspond to the amount of input $i = 1, 2, \ldots, m$ employed by hospital_o and y_{ro} are the amount of output $r = 1, 2, \ldots, s$ produced by hospital_o. Hospital_o is the hospital_j under evaluation (related to all the hospital_j, including itself) through model (1). A hospital is technically efficient when $\theta^*_{CRS} = 1$ or, that is, it cannot reduce its inputs without worsening at least one of its outputs.

To allow for the variable returns to scale (VRS) technology the convexity constraint of $\sum_{j=1}^{n} \lambda_j = 1$ (Banker et al. 1984) is added to the model (1). This new model is called BCC-DEA or VRS. From an empirical perspective, the difference between CRS and VRS models is the fact that the VRS model considers the scale effect. More precisely, scale efficiency (SE) can be measured through the ratio between the two models (CRS and VRS). SE measures the savings of resources which would occur if the scale of operation was optimal. Technical efficiency in both models obeys to the relation $0 \leq \left(\theta^*_{crs}\right) \leq \left(\theta^*_{vrs}\right) \leq 1$.

3.2 Congestion efficiency

3.2.1 FGL approach

The measurement of congestion inefficiency by the FGL approach is based on the comparison between two models where a distinction between the "strong disposal" from the "weak disposal" is carried out. The first one, related to the condition of strong disposability, is described by model (1). The second one, corresponding to the weak (input) disposal situation is given by:

$$\begin{aligned} &\theta^*_{weak} = \min \theta \\ &\text{s.t.} \quad \sum_{j=1}^{n} x_{ij}\lambda_j - \theta x_{io} = 0 \qquad i = 1, 2, \ldots, m, \\ &\qquad y_{ro} - \sum_{j=1}^{n} y_{rj}\lambda_j \geq 0 \qquad r = 1, 2, \ldots, s, \\ &\qquad \lambda_j \geq 0 \qquad\qquad\qquad j = 1, 2, \ldots, n. \end{aligned} \tag{2}$$

The comparison between model (1) with VRS and model (2) allows for the measurement of congestion efficiency. The assumption of a more restrictive constraint in model (2) leads to the relationship $0 \leq \theta^*_{CRS} \leq \theta^*_{VRS} \leq \theta^*_{CONG}$. A hospital$_o$ highlights signs of congestion if and only if $\theta^*_{CONG} < 1$. Contrarily, in case of $\theta^*_{CONG} = 1$, there is absence of congestion inefficiency.

3.2.2 CGL approach

CGL approach computes the congestion considering the inclusion of slacks into the objective function. Firstly, CGL use the algorithm (3) adopting an output orientation where ε is a non-Archimedean value ($\varepsilon > 0$):

$$\begin{aligned} &\max \quad \theta_o + \varepsilon\left(\sum_{r=1}^{s} s_r^+ + \sum_{i=1}^{m} s_i^-\right) \\ &\text{s.t.} \quad \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta_o x_{io} \qquad i = 1, 2, \ldots, m, \\ &\qquad \sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro} \qquad r = 1, 2, \ldots, s, \\ &\qquad \sum_{j=1}^{n} \lambda_j = 1 \\ &\qquad s_i^-, s_r^+, \lambda_j \geq 0 \qquad\qquad j = 1, \ldots, n. \end{aligned} \tag{3}$$

Secondly, it uses a second stage (Brockett et al. 1998) as follows (4):

$$\begin{aligned}
\max \quad & \sum_{i=1}^{m} \delta_i^{+} \\
\text{s.t.} \quad & \sum_{j=1}^{n} x_{ij}\widehat{\lambda}_j - \delta_i^{+} = \theta_o^{*}\widehat{x}_{io} && i = 1, 2, \ldots, m, \\
& \sum_{j=1}^{n} y_{rj}\widehat{\lambda}_j = \widehat{y}_{ro} && r = 1, 2, \ldots, s, \\
& \sum_{j=1}^{n} \widehat{\lambda}_j = 1 \\
& s_i^{-*} \geq \delta_i^{+} && \forall i, \\
& \widehat{\lambda}_j, \delta_i^{+} \geq 0 && \forall i, j.
\end{aligned} \tag{4}$$

The variables x_{io} and y_{ro} used in algorithm (3) are replaced in algorithm (4) by new values $\widehat{x}_{io}$ ($\leq x_{io}$) and $\widehat{y}_{ro}$ ($\geq y_{ro}$), which are defined below:

$$\begin{aligned}
\widehat{x}_{io} &= x_{io} - s_i^{-*} \quad i = 1, 2, \ldots, m, \\
\widehat{y}_{ro} &= y_{ro} - s_r^{+*} \quad r = 1, 2, \ldots, s.
\end{aligned} \tag{5}$$

CGL identified as inefficiency both non-zero slacks and values of $\theta_o^{*} < 1$. Thus, a hospital$_o$ is efficient if and only if $\widehat{x}_{io} = x_{io}$ and $\widehat{y}_{ro} = y_{ro}$ for every i and r in Eq. (5). Like this, the amount of congestion s_i^{c} as defined next in Eq. (6) is obtained by the difference between each pair of s_i^{-*} and δ_i^{+*}:

$$s_i^{c} = s_i^{-*} - \delta_i^{+*} \quad i = 1, 2, \ldots, m. \tag{6}$$

Here s_i^{c} is the quantity of input i associated with congestion and δ_i^{+*} represents the technical inefficiency. Therefore, Eq. (6) can be written as follows:

$$s_i^{c}/x_i = s_i^{-*}/x_i - \delta_i^{+*}/x_i, \tag{7}$$

In Eq. (7), s_i^{c}/x_i refers to the amount of congestion in input i, s_i^{-*}/x_i corresponds to the slack in input i, and the δ_i^{+*}/x_i is the share of technical inefficiency in the respective input. By taking the arithmetic means over all inputs, the final expression of congestion (C_{Co}) considering the average effect of each input is given by:

$$C_{Co} = \overline{s/x} - \overline{\delta/x} \tag{8}$$

where C_{Co} has values between zero and one.

3.2.3 TS approach

Tone and Sahoo (2004) proposed a new two-stage method to measure congestion using the slacks-based measure (SBM) in the second stage (Tone 2001). The SBM formulation (in an output orientation) is given by:

$$\max \frac{1}{s}\sum_{r=1}^{s}\frac{t_r^+}{y_{ro}} + \varepsilon\frac{1}{m}\sum_{i=1}^{m}\frac{t_i^-}{x_{io}} \tag{9}$$

Here $t_r^+ (r = 1, \ldots, s)$ and t_r^- $(i = 1, \ldots, m)$ correspond respectively to the existence or not of congestion.

TS approach distinguishes between strong and weak congestion. In a practical view the former corresponds to the congestion of all inputs whereas the latter occurs when not all the inputs are congested. Algebraically, strong congestion of a hospital (x_o, y_o) is defined by the existence of an activity $(\tilde{x}_o, \tilde{y}_o) \in P_{\text{convex}}$ such that $\tilde{x}_o = \alpha x_o$ (with $0 \leq \alpha \leq 1$) and $\tilde{y}_o = \beta y_o$ (with $\beta > 1$). Weak congestion exists if a hospital is strongly efficient with respect to P_{convex} and if there is an activity in P_{convex} that uses fewer resources in one or more outputs.

Other advantage of TS approach is to provide a relationship between scale economies and congestion. It allows for the determination of the scale effect (DSE) through the expression below:

$$DSE = -\frac{\frac{1}{s}\sum_{r=1}^{s}\frac{t_r^{+*}}{y_{ro}}}{\frac{1}{m}\sum_{i=1}^{m}\frac{t_i^{-*}}{x_{io}}} \tag{10}$$

The scale diseconomy (ρ) can be determined by the ratio between the change in y by the change in x. Therefore, TS procedure measures the potential increase in output from eliminating the congestion of inputs. This is true only for the case of existence of strong congestion $(\rho < 0)$. When weak congestion occurs $(\rho > 0)$, this issue needs to be handled differently.

4 Measuring the portuguese hospital efficiencies

4.1 Model specification and data

The selection of inputs and outputs is always a critical decision when performing an efficiency analysis. Basically, we should guarantee that the model is truly reflecting the real world (Ozcan 2008). An incorrect or less careful specification of variables may lead to biased results. In hospital performance studies, the selection of variables is especially difficult, in particular due to the wide range of services provided by each one. However, there are some variables which are consensual in the literature, which makes the work easier (Hollingsworth 2003; Hofmarcher et al. 2005; O'Neill et al. 2008; Lobo et al. 2009).

Table 1 Hospital variables descriptive statistics (2005)

	Mean	SD	Median	Min.	Max.
Outputs					
Patients (no.)	11,152	9,740	8,289	622	47,145
Emergency visits (no.)	84,199	56,724	70,561	0	235,111
Outpatient visits (no.)	108,584	106,092	70,411	9,941	477,020
Inputs					
CAPEX (€)	1,752,597	1,913,697	1,046,642	9,919	8,415,052
Staff (no.)	1,143	1,167	860	137	5,103
OOPEX (€)	29,968,567	38,781,204	17,433,299	1,704,650	203,956,464

This study encompasses as inputs: (a) capital expenses (CAPEX), which is measured through the net assets (that includes the intangible assets, the tangible assets and the financial assets), (b) number of full-time employees (Staff) and (c) other operational expenses (OOPEX), which is measured through the OPEX, subtracting the staff costs part. As outputs, it considers the number of patients treated at hospital services, the number of emergency visits, and the number of outpatients' visits.

Considering the provision of the health care services as public service (without profit purposes), it induces the clear idea of adopting an input orientation for this model, despite of not being a consensual aspect in other public sector areas (airports for instance). This research was carried out with a set of data from 68 hospitals relative to the year 2005. Most of the data were directly provided by the hospitals (account annual reports). However, it was necessary to establish a direct contact with some hospitals to obtain the information missing. The basic statistics for each variable are given in Table 1.

4.2 DEA

The application of the DEA technique, using input orientation, allowed the evaluation of Portuguese hospitals performance for the year 2005. Two models (CRS and VRS) were computed for this purpose. Table 2 provides the technical efficiency estimates including the scale effect and the nature of returns to scale (RTS) for each hospital. The results show that 11 hospitals out of 68 are efficient under the CRS model and 26 under the VRS model. As expected, the VRS model scores bring to light more efficiency than those of the CRS model. Concerning the technical efficiency, the VRS model presents an average value of 0.863 whereas the CRS model depicts an average score of 0.739. The latter encompasses the scale inefficiency contribution as well. The results obtained suggest that on average the Portuguese hospitals could reduce their inputs (CAPEX, staff, and OOPEX) in 13.7% under the VRS model (or 26.1% under the CRS model) producing the same outputs (patients, emergency visits, outpatients visits).

The results point out that a significant portion of inefficiency is caused by scale diseconomies. This means that Portuguese hospitals could save on average 14.4% of

Table 2 Technical efficiency, SE and RTS of Portuguese hospitals in 2005

	Hospital	θ_{CRS}	θ_{VRS}	SE	RTS
1	H. Universidade de Coimbra	0.555	1.000	0.555	DRS
2	H. São João	0.506	1.000	0.506	DRS
3	H. Santa Maria, EPE	0.522	1.000	0.522	DRS
4	C.H. Lisboa	0.407	0.728	0.559	DRS
5	H. São Teotónio, EPE	0.758	1.000	0.758	DRS
6	C.H. Coimbra	0.455	0.887	0.513	DRS
7	H. Geral Santo António, EPE	0.614	1.000	0.614	DRS
8	H. Braga	0.715	1.000	0.715	DRS
9	C.H. Gaia	0.557	1.000	0.557	DRS
10	H. Garcia de Orta, EPE	0.580	0.825	0.702	DRS
11	C.H. Alto Minho, EPE	0.727	0.922	0.788	DRS
12	H. Senhora da Oliveira, EPE	0.921	1.000	0.921	DRS
13	H. Faro	0.627	0.842	0.744	DRS
14	C.H. Médio Tejo, EPE	0.662	1.000	0.662	DRS
15	Unidade Local de Saúde de Matosinhos, EPE	0.664	0.806	0.824	DRS
16	H. Santo André, EPE	0.763	1.000	0.763	DRS
17	H. Curry Cabral	0.539	0.685	0.787	DRS
18	H. Padre Américo Vale do Sousa, EPE	0.819	0.981	0.835	DRS
19	C.H. Vila Real Peso da Régua, EPE	0.856	1.000	0.856	DRS
20	H. Évora	0.614	0.832	0.739	DRS
21	H. Santarém	0.684	0.871	0.784	DRS
22	H. Infante Dom Pedro, EPE	0.761	0.882	0.863	DRS
23	C.H. Cova da Beira, EPE	0.576	0.659	0.875	DRS
24	H. Guarda	0.789	0.890	0.886	DRS
25	H. São Sebastião, EPE	1.000	1.000	1.000	CRS
26	H. Castelo Branco	0.606	0.609	0.995	DRS
27	IPOFG Lisboa, EPE	0.373	0.549	0.679	DRS
28	C.H. Barlavento Algarvio, EPE	0.643	0.643	1.000	DRS
29	C.H. Torres Vedras	0.615	0.653	0.943	DRS
30	C.H. Baixo Alentejo, EPE	0.505	0.506	0.997	IRS
31	H. Portalegre	1.000	1.000	1.000	CRS
32	IPOFG-CRO Coimbra, EPE	0.653	0.701	0.931	DRS
33	C.H. Cascais	0.585	0.716	0.817	DRS
34	H. Chaves	0.676	0.703	0.961	DRS
35	H. Estefânia	0.472	0.828	0.571	DRS
36	H. Santa Marta, EPE	0.498	0.526	0.946	DRS
37	H. Vila Franca de Xira	0.864	0.979	0.883	DRS
38	H. Santa Maria Maior, EPE	0.980	1.000	0.980	DRS
39	H. São Gonçalo, EPE	1.000	1.000	1.000	CRS
40	H. Distrital Figueira da Foz, EPE	0.744	0.815	0.913	DRS

Table 2 continued

	Hospital	θ_{CRS}	θ_{VRS}	SE	RTS
41	C.H. Póvoa Varzim Vila Conde	0.996	1.000	0.996	DRS
42	H. Lamego	1.000	1.000	1.000	CRS
43	H. São João da Madeira	0.888	0.938	0.947	DRS
44	C.H. Caldas da Rainha	0.511	0.526	0.972	DRS
45	Maternidade Júlio Dinis	1.000	1.000	1.000	CRS
46	H. Elvas	0.677	0.756	0.895	IRS
47	H. Fafe	0.811	0.907	0.894	IRS
48	H. Maria Pia	1.000	1.000	1.000	CRS
49	H. Outão	0.466	0.526	0.887	IRS
50	H. Oliveira de Azemeis	0.982	1.000	0.982	DRS
51	H. Litoral Alentejano	0.524	0.567	0.924	IRS
52	H. Montijo	0.707	0.734	0.963	IRS
53	H. Ovar	0.858	0.890	0.964	IRS
54	H. Valongo	1.000	1.000	1.000	CRS
55	H. Alcobaça	1.000	1.000	1.000	CRS
56	H. Joaquim Urbano	0.561	0.870	0.645	IRS
57	H. Seia	0.915	0.949	0.964	IRS
58	H. Pombal	0.800	0.898	0.891	IRS
59	H. Cantanhede	1.000	1.000	1.000	CRS
60	H. Tondela	0.970	0.992	0.978	IRS
61	H. Peniche	0.819	0.856	0.957	IRS
62	H. Estarreja	0.965	1.000	0.965	IRS
63	H. Anadia	0.913	0.914	0.999	IRS
64	H. Espinho	0.720	0.872	0.826	IRS
65	Instituto Gama Pinto	1.000	1.000	1.000	CRS
66	H. Pulido Valente, EPE	0.334	0.512	0.653	DRS
67	C.H. Nordeste, EPE	1.000	1.000	1.000	CRS
68	C.H. Médio Ave	0.924	0.935	0.988	DRS
Average		0.739	0.863	0.856	

the inputs consumed if they operated at an optimal scale. Concerning the RTS, the sample is dominated by decreasing returns to scale (DRS). Only 15 hospitals have increasing returns to scale (IRS) and 11 have CRS.

Table 2 shows the H. São Sebastião (25), H. Portalegre (31), H. São Gonçalo (39), H. Lamego (42), Maternidade Júlio Dinis (45), H. Maria Pia (48), H. Valongo (54), H. Alcobaça (55), H. Cantanhede (59), Instituto Gama Pinto (65) and the H.C. Nordeste (67) as efficient hospitals according to the CRS model, and the C. H. Lisboa (4), C. H. Coimbra (6), IPOFG of Lisbon (27), H. Outão (49) and the H. Pulido Valente (66) with the 5 worst performances under the CRS model.

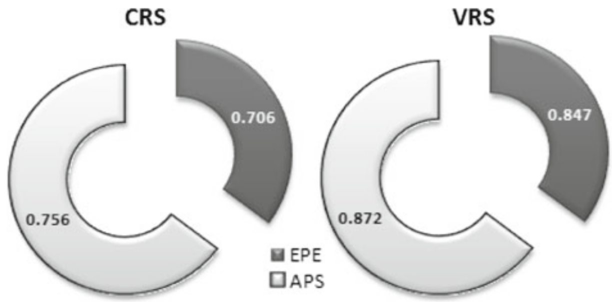

Fig. 2 Efficiency of EPE and APS hospitals (CRS and VRS models) in 2005

4.3 Analysis of DEA results

From the results obtained through the DEA model, some ideas come abroad about the optimal scale for Portuguese hospitals. The analysis of the hospital RTS allows to infer that a hospital that treats 6,000 patients, receives 60,000 emergency visits and handles 50,000 outpatient visits has the optimal scale for the provision of these services. Anyway, these results cannot be considered as definite, since the operational and institutional environment (e.g., the case-mix index or the type of management, respectively) may influence efficiency considerably. However, this is an important figure for the decision-makers.

Comparing the type of management of the Portuguese hospitals, we obtain the following results, given in Fig. 2. The figure proves that APS hospitals are more efficient than EPE hospitals, both under CRS and VRS models. It indicates that the reforms which took place in the sector recently seem to be, a priori, unsuccessful.

The District Hospitals were also compared with Central Hospitals. We found that the former are on average more efficient than the latter under the CRS model and more inefficient when the VRS model is applied. This can be justified by the fact that the technology of production in the Portuguese hospitals presents mainly DRS. This result is line with the literature which frequently points out the existence of diseconomies of scale in hospital services (see, for example, McKillop et al. 1999 and Wang et al. 2006). Indeed, when the effect of scale economies is accounted for smaller District Hospitals they have higher efficiency but when this effect is removed they display lower efficiency. This can be observed in Fig. 3.

The average efficiency results comparing the amalgamated hospitals (Hospital Centres) with the single ones (Single Hospitals) are presented in Fig. 4. One more time, the average results reveal that the reforms carried out in the last years (merger and amalgamation of hospitals) have not produced positive effects yet, quite the opposite, the Hospital Centres are on average less efficient than the single ones. This can be related not only to the scale economies already mentioned but also to the diseconomies of scope, as the literature also points out (see Wholey et al. 1996 and Kittelsen and Magnussen 2003).

The analysis per region of Portugal provides evidence that the hospitals in the North and Centre of the country have the best performance, as supported by Fig. 5.

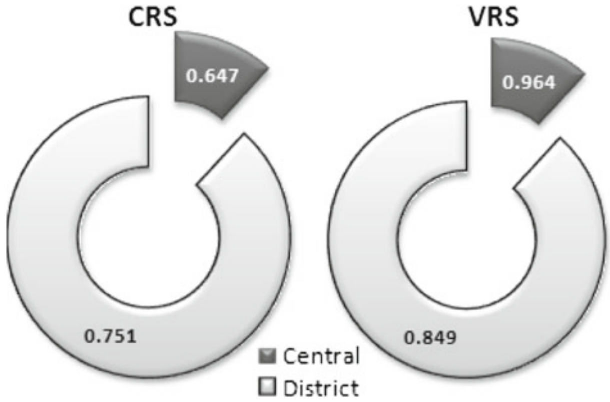

Fig. 3 Efficiency of central and district hospitals (CRS and VRS models) in 2005

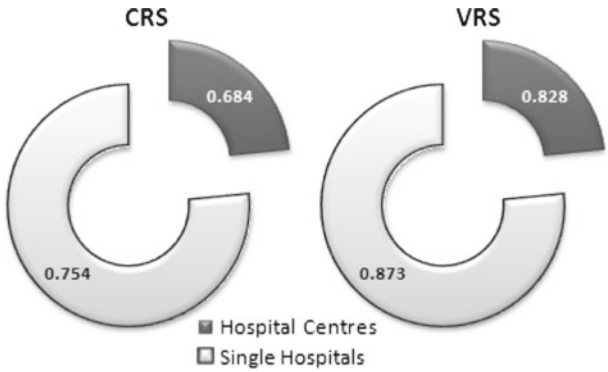

Fig. 4 Efficiency for hospital centres and single hospitals (CRS and VRS models) in 2005

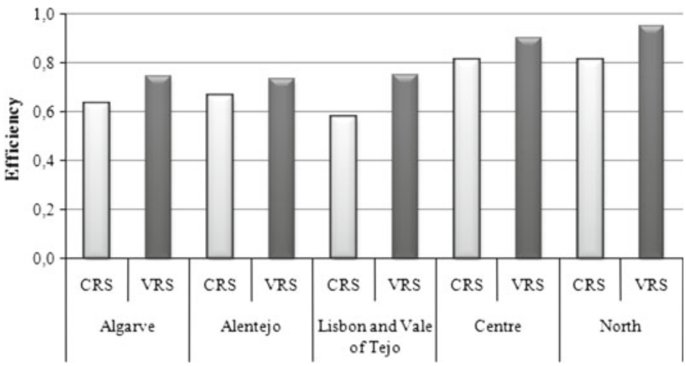

Fig. 5 Efficiency of Portuguese hospitals per region (CRS and VRS models) in 2005

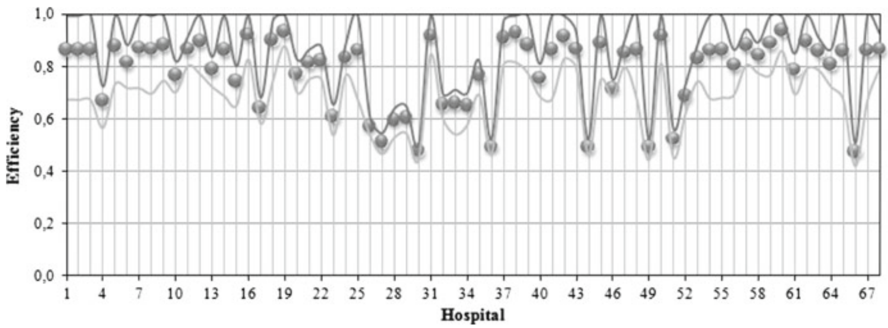

Fig. 6 Bootstrap corrected efficiencies and confidence intervals for 2005

Despite the conclusions that could be taken from the different analyzes carried out (i.e., EPE vs. APS hospitals, Central vs. District hospitals, Hospital Centres vs. Single Hospitals and Portuguese Region), we did not find statistical significance in the samples through the application of the Mann–Whitney U test.

Following Simar and Wilson (1998), to confer some robustness to our results, the bootstrap methodology is applied. The results (for the VRS model) obtained are displayed in Fig. 6 where the confidence intervals are also presented. We adopted a 95% significance level and a number of replications of 2000.

As it is well known, the measurement of efficiencies without considering the operational environment implies that some important information is missing (De Witte and Marques 2009). Thus, this study applies a second-stage methodology, called double-bootstrap, proposed by Simar and Wilson (2007), which improves considerably the traditional Tobit regression. Following them, a (semi-parametric) regression analysis (after the DEA-VRS model in the first stage) is carried out to determine the influence of environmental variables on the bias-corrected efficiency scores:

$$\theta_j = \beta + Z_j\alpha + \varepsilon_j \quad j = 1, \ldots, n \tag{11}$$

where β is a constant term, ε_j the statistical noise, Z_j represents the explanatory variables that can be related to technical efficiency θ_j of the hospital$_j$.

In this case, the study encompasses the case-mix index, the occupation rate, the type of hospital management (dummy with the value of 1 attributed to EPE hospitals and of 0 to APS hospitals), the amalgamation of hospitals (dummy with the value of 1 attributed to amalgamated hospitals (Hospital Centres) and of 0 to Single Hospitals), the teaching hospitals (dummy with the value of 1 attributed to teaching hospitals and of 0 to non-teaching hospitals), and the percentage of doctors in the staff as the explanatory variables to describe the operational environment of hospital services. Beyond the importance of each variable (from t-value), the results of double-bootstrap also give us their influence on hospital efficiency through their sign. The results are presented in Table 3.

From these results, it is possible to conclude that the occupation rate and the teaching hospitals have a positive relationship with efficiency. The literature generally also points out the teaching hospitals as more efficient (see, for example,

Table 3 Double bootstrap (VRS) results summary in 2005

Variables	Estimate	Lower bound	Upper bound	t-value
Intercept	1.3047	−2.0019	3.7965	12.7700
Case-mix index	0.5325	0.0470	0.9719	33.4400
Occupation rate	−0.4988	−3.0141	1.9631	−5.2583
Type of hospital	0.1720	−0.4368	0.8775	7.5176
% Doctors	0.0084	−0.0352	0.0524	5.7517
Amalgamation	0.0005	−0.4726	0.3187	3.9876
Teaching hospitals	−0.2543	0.8958	−0.3889	−10.6202
SD	0.2668	0.1502	0.4229	49.2084

Ferrier and Valdmanis 2006 or Grosskopf et al. 2004). On the contrary, the case-mix index, the percentage of doctors and the type of hospital management and their amalgamation have a negative effect on hospital efficiency. The first two explanatory factors are consistent with the literature (see for the case-mix index Björkgren et al. 2004 and for the percentage of doctors Jacobs et al. 2006). The third and fourth factors corroborate the previous analysis of the DEA results where it was possible to observe that APS hospitals had better performance than EPE hospitals similarly to the Single Hospitals when compared with the Hospital Centres.

5 Congestion of Portuguese hospitals

5.1 FGL approach

Following FGL, the congestion is measured through the ratio between strong efficiency and weak efficiency. In 68 hospitals, 29 show signs of congestion, which, on average, means that the Portuguese hospitals are 3.6% congested. However, congestion increases to 8.1% in hospitals when we consider just the congested ones. This means that if these hospitals are congestion efficient (equal to 1 or 100%) they could reduce 8.1% of their inputs (CAPEX, Staff, and OOPEX) producing the same outputs. Figure 7 presents the strong and weak efficiencies and the corresponding congestion proportion of the 68 Portuguese hospitals analyzed. The higher levels of congestion (more than 20%) are observed in the H.C. Cova da Beira (23), H. Litoral Alentejano (51) and H. Montijo (52). Indeed, the more resources these hospitals consume the less outputs they produce. The distortion of capacity of inputs that exists in these hospitals can be associated with their location, which encompasses substantial seasonal population (depending on whether it is Summer or Winter).

The robustness of the results can be attested by comparison between the CRS and VRS assumptions in the approach. Considering this analysis, we can accept the results obtained from the VRS method because globally the congestion proportions are similar for the same hospitals. Figure 8 presents the results obtained by both DEA assumptions (CRS and VRS).

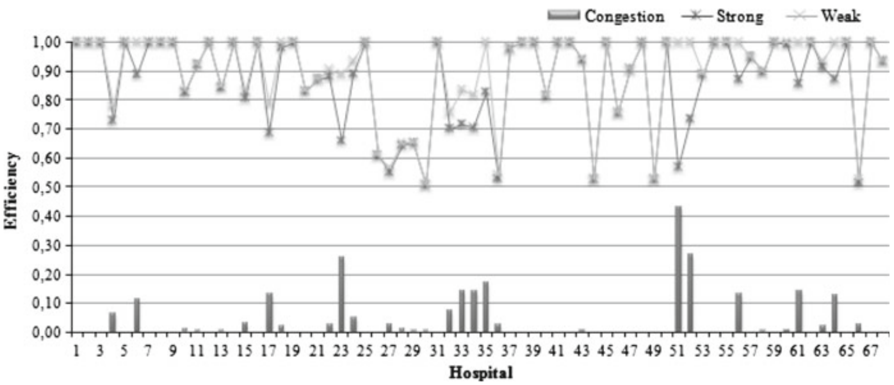

Fig. 7 Strong and weak efficiencies and congestion obtained by the FGL approach for 2005

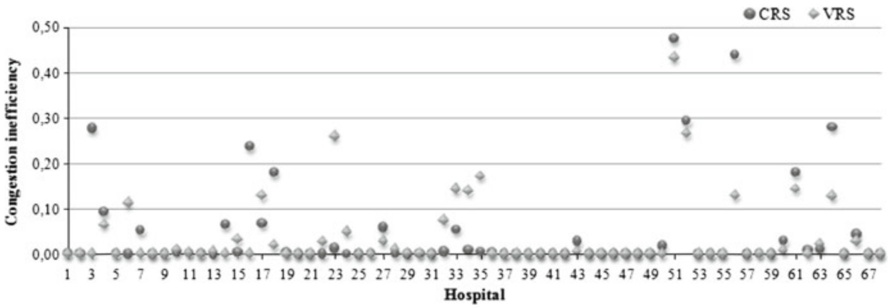

Fig. 8 Differences in congestion between CRS and VRS methods in 2005

FGL procedure allows for the technical efficiency decomposing, as given:

$$\theta_{\text{CRS}} = \theta_{\text{VRS}} \times \text{SE} \times \theta_{\text{CONG}} \tag{12}$$

where θ_{CRS} is the technical efficiency obtained with the CRS model (known as overall technical efficiency), θ_{VRS} is the technical efficiency computed with the model VRS (sometimes called pure technical efficiency), SE is the already mentioned scale efficiency, and θ_{CONG} is congestion efficiency. Table 4 presents the results obtained for the technical efficiency decomposition. Notice that only the hospitals with congestion signs are presented in the table.

5.2 CGL approach

This approach has the advantage of revealing what (input) is causing this congestion. With CGL approach, the results show that 35 hospitals are congested. Table 5 shows the influence of each input on the congestion of each hospital. Similarly to Table 4, only the hospitals with congestion signs are here presented. With this approach, the H.C. Lisbon (4), H.C. Coimbra (6), H. Padre Américo Vale do Sousa (18), and

Table 4 Decomposition of technical efficiency in 2005

Hospital	θ_{CRS}	θ_{VRS}	VRS assumption		CRS assumption	
			SE	θ_{CONG}	SE	θ_{CONG}
1	0.555	1.000	0.555	1.000	0.557	0.997
2	0.506	1.000	0.506	1.000	0.507	0.998
3	0.522	1.000	0.522	1.000	0.721	0.724
4	0.407	0.779	0.559	0.935	0.577	0.906
5	0.758	1.000	0.758	1.000	0.759	0.999
6	0.455	1.000	0.513	0.887	0.455	1.000
7	0.614	1.000	0.614	1.000	0.649	0.947
10	0.580	0.833	0.702	0.991	0.699	0.995
11	0.727	0.924	0.788	0.997	0.789	0.997
12	0.921	1.000	0.921	1.000	0.923	0.999
13	0.627	0.847	0.744	0.995	0.741	1.000
14	0.662	1.000	0.662	1.000	0.708	0.934
15	0.664	0.833	0.824	0.968	0.801	0.996
16	0.763	1.000	0.763	1.000	1.000	0.763
17	0.539	0.788	0.787	0.870	0.734	0.933
18	0.819	1.000	0.835	0.981	1.000	0.819
22	0.761	0.906	0.863	0.973	0.840	1.000
23	0.576	0.888	0.875	0.741	0.657	0.987
24	0.789	0.935	0.886	0.951	0.844	0.999
25	1.000	1.000	1.000	1.000	1.000	1.000
27	0.373	0.565	0.679	0.972	0.701	0.941
28	0.643	0.650	1.000	0.989	0.991	0.998
29	0.615	0.653	0.943	0.999	0.942	1.000
30	0.505	0.507	0.997	0.999	0.997	0.998
32	0.653	0.757	0.931	0.925	0.866	0.995
33	0.585	0.836	0.817	0.856	0.740	0.946
34	0.676	0.818	0.961	0.860	0.835	0.990
35	0.472	1.000	0.571	0.828	0.475	0.994
36	0.498	0.541	0.946	0.973	0.924	0.996
43	0.888	0.944	0.947	0.994	0.969	0.971
51	0.524	1.000	0.924	0.567	1.000	0.524
52	0.707	1.000	0.963	0.734	1.000	0.707
56	0.561	1.000	0.645	0.870	1.000	0.561
58	0.800	0.899	0.891	0.999	0.892	0.998
60	0.970	1.000	0.978	0.992	1.000	0.970
61	0.819	1.000	0.957	0.856	1.000	0.819
62	0.965	1.000	0.965	1.000	0.974	0.991

Table 4 continued

Hospital	θ_{CRS}	θ_{VRS}	VRS assumption		CRS assumption	
			SE	θ_{CONG}	SE	θ_{CONG}
63	0.913	0.935	0.999	0.978	0.988	0.989
64	0.720	1.000	0.826	0.872	1.000	0.720
66	0.334	0.527	0.653	0.972	0.663	0.956
Average				0.962		0.955

H. Espinho (64) have the highest congestion inefficiency. In particular, as these hospitals are older, this may lead to an inefficient (congested) use of inputs.

5.3 TS approach

The results obtained from the TS approach revealed congestion signs for Portuguese hospitals ranging between 3.3% (considering all the hospitals) and 8.2% (only for congested ones). As referred before, in addition, TS procedure has the feature of evaluating the scale diseconomies, via parameter ρ. Figure 9 shows the corresponding values of congestion and scale diseconomies per hospital. As we can observe, the H. Litoral Alentejano (51), H. Montijo (52), H. Joaquim Urbano (56), and H. Espinho (64) reveal the higher levels of congestion inefficiencies. The reasons for the high congestions found in these hospitals are possibly the ones already referred to for the other hospitals.

The computation of ρ has an important and specific meaning, that is, if a decrease of 1% in congested inputs exists, the outputs production has on average a potential improvement of about 2.5% (mean of the ρ value).

The results from this approach are presented in Fig. 9.

5.4 Comparison between the different approaches

The comparison between the different approaches shows that the congested hospitals, most of the times, coincide among them. So, only in that situation are we able to infer about their congestion. Figure 10 presents the similarities and deviations among the results and congestion averages for each method. Therefore, it is easy to observe that the H.C. Lisbon (4), H.C. Alto Minho (11), H.L.U. Matosinhos (15), H. Curry Cabral (17), H. Padre Américo Vale do Sousa (18), H.C. Cova da Beira (23), H. Guarda (24), H.C. Barlavento Algarvio (28), IPOFG-CRO Coimbra (32), H.C. Cascais (33), H. Chavez (34), H. Estefânia (35), H. Santa Marta (36), H. São João da Madeira (43), H. Litoral Alentejo (51), H. Montijo (52), H. Joaquim Urbano (56), H. Pombal (58), H. Tondela (60), H. Peniche (61), H. Anadia (63) and H. Espinho (64) show important signs of congestion. As figure shows, FGL (CRS) and TS denote the most congruent results.

Table 5 Results obtained from CGL approach in 2005

Hospital	OOPEX		Staff		CAPEX		Overall θ_{CONG}
	Tech. ineff.	Cong.	Tech. ineff.	Cong.	Tech. ineff.	Cong.	
...	...	...	...	...	...	...	...
4	0.000	0.603	0.000	0.420	0.000	0.000	0.341
6	0.000	0.385	0.000	0.369	0.000	0.000	0.251
10	0.000	0.179	0.000	0.000	0.000	0.000	0.060
11	0.000	0.150	0.000	0.000	0.000	0.000	0.050
13	0.000	0.275	0.000	0.000	0.000	0.000	0.092
15	0.000	0.348	0.000	0.000	0.000	0.000	0.116
17	0.000	0.527	0.000	0.000	0.000	0.000	0.176
18	0.000	0.000	0.000	0.150	0.000	0.453	0.201
20	0.045	0.151	0.000	0.000	0.000	0.000	0.050
21	0.007	0.059	0.000	0.000	0.000	0.000	0.020
22	0.000	0.000	0.048	0.015	0.000	0.000	0.005
23	0.000	0.000	0.019	0.167	0.000	0.000	0.056
24	0.000	0.000	0.104	0.043	0.000	0.000	0.014
26	0.000	0.091	0.000	0.000	0.000	0.000	0.030
27	0.000	0.183	0.000	0.000	0.000	0.000	0.061
28	0.000	0.119	0.000	0.000	0.000	0.000	0.040
29	0.000	0.000	0.000	0.004	0.000	0.000	0.001
30	0.000	0.042	0.000	0.000	0.000	0.000	0.014
32	0.000	0.367	0.000	0.000	0.000	0.000	0.122
33	0.165	0.161	0.000	0.043	0.000	0.000	0.068
34	0.000	0.000	0.028	0.136	0.000	0.000	0.045
35	0.000	0.000	0.041	0.211	0.000	0.000	0.070
36	0.000	0.331	0.000	0.000	0.000	0.000	0.110
43	0.070	0.000	0.000	0.000	0.000	0.107	0.036
44	0.000	0.076	0.000	0.000	0.000	0.000	0.025
51	0.004	0.586	0.000	0.000	0.000	0.000	0.195
52	0.000	0.000	0.000	0.181	0.000	0.000	0.060
56	0.045	0.805	0.000	0.000	0.000	0.268	0.358
57	0.095	0.113	0.000	0.000	0.000	0.000	0.038
58	0.146	0.000	0.000	0.000	0.000	0.060	0.020
60	0.000	0.000	0.000	0.000	0.042	0.451	0.150
61	0.000	0.000	0.000	0.110	0.000	0.000	0.037
63	0.000	0.000	0.000	0.000	0.081	0.029	0.010
64	0.030	0.628	0.000	0.000	0.000	0.000	0.209
66	0.054	0.136	0.000	0.000	0.000	0.000	0.045
68	0.000	0.000	0.000	0.028	0.000	0.000	0.009
Average		0.093		0.028		0.020	0.047

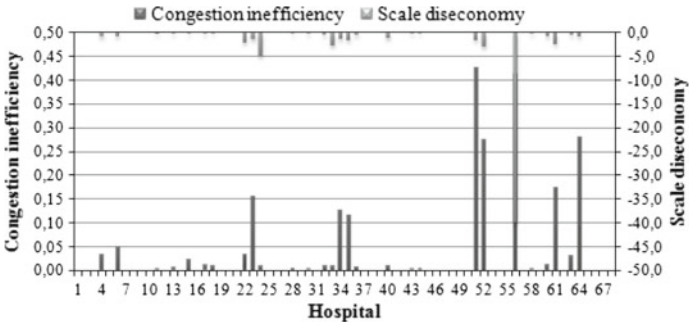

Fig. 9 Congestion inefficiencies and scale diseconomies in 2005

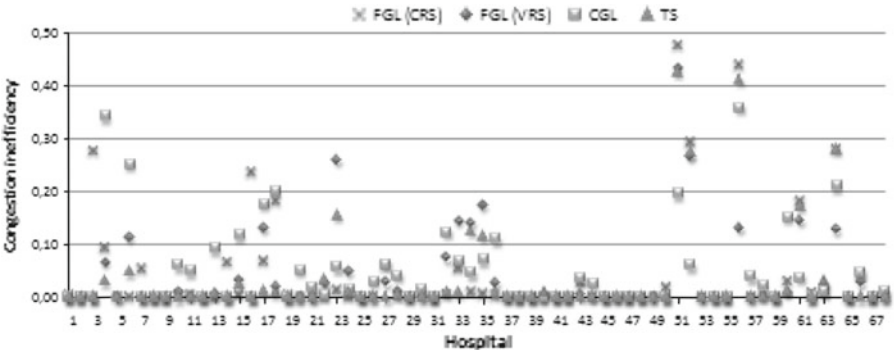

Fig. 10 Comparison between the different approaches to compute congestion in 2005

6 Conclusions

Congestion is absolutely an important issue of hospital production. Managers should therefore improve demand forecasting capabilities, manage the flow of arrivals, or reorganise critical components of service delivery in order to reduce congestion (Brailer 1992). Hospitals may reduce congestion by creating autonomous production units instead of traditional hospital wards, so that hospital-wide effects of congestion can be minimized. Anyway, this research ends up with a clear idea that more research should be performed about dynamic aspects of hospital care.

This research evaluated the performance of 68 Portuguese hospitals through the non-parametric frontier method of DEA, which pointed out significant levels of inefficiency. For instance, using CRS and VRS models an average level of 26.1% and 13.7% of inefficiency, respectively, were estimated. Besides, if hospitals operated in an optimal size, they would be able to save about 14.4% of their costs (inputs consumed) for the same quantity of outputs produced.

The DEA results seem to point out that APS Hospitals had better performance than EPE hospitals, both under CRS and VRS models. This indicates that the recent reforms are not being successful. Although the reforms could take some time to produce effects and in an initial stage the costs could be higher, these reasons surely influence the results. They can indicate as well some excess of deregulation of the EPE Hospitals and consequently some absence of accountability which may have allowed them to spend (and waste) more resources more easily than the APS Hospitals. Concerning the Central and District Hospitals analysis, the results proved that the District ones are more efficient, under the CRS model, and less efficient, under the VRS model, than the Central Hospitals, as it was expected and taking into account the scale effect differences between the two models. The comparison of the average efficiency between Hospital Centres and Single Hospitals also indicate that the reforms are not achieving the results predicted since the Single Hospitals are more efficient. Moreover, this study allowed us to find that the hospitals from the North and the Centre of Portugal are the most efficient ones. Accounting for the operational environment showed that, except for the occupation rate, all the other variables (case-mix index, type of hospital management, and percentage of doctors) had a negative effect on hospitals' efficiency. These results are according to the expected and to the literature.

In a second part of this paper, the congestion inefficiency was estimated and the scores of three distinct approaches were compared, respectively the FGL, CGL, and TS approaches. In the FGL approach, the different assumptions (CRS and VRS) to measure congestion indicate some differences between them. When the all sample is considered, the congestion proportions diverge between 4.4% (CRS) and 3.6% (VRS). The FGL congestion results are considerably higher when only the congested hospitals are taken into account, varying between 7.8% (CRS) and 8.1% (VRS). CGL approach revealed congestion signs a little higher than the previous ones. An average congestion value of 4.8% was obtained when the whole sample was considered and 9.0% only for the congested hospitals. Moreover, this method allows for the perception of the input(s) contribution to the congestion score. In our case, OOPEX was identified as the most important contributor. TS approach, reflecting slightly different scores from the previous ones, shows signs of congestion of 3.3% and 8.2% when the set of Portuguese hospitals is considered and when the sample is restricted to the congested ones, respectively.

In short, the computation of the three approaches enabled us to argue that the H.C. Lisbon, H.C. Alto Minho, H.L.U. Matosinhos, H. Curry Cabral, H. Padre Américo Vale do Sousa, H.C. Cova da Beira, H. Guarda, H.C. Barlavento Algarvio, IPOFG-CRO Coimbra, H.C. Cascais, H. Chavez, H. Estefânia, H. Santa Marta, H. São João da Madeira, H. Litoral Alentejo, H. Montijo, H. Joaquim Urbano, H. Pombal, H. Tondela, H. Peniche, H. Anadia, and H. Espinho are surely congested since all the procedures proved the existence of congestion. So, in these hospitals, a potential expansion of the service should be carefully conducted. The presence of congestion in other hospitals depends on the approach adopted. Although more research is needed, especially in the presence of congestion signs, important consequences are perceptible as far as technical inefficiency is concerned.

Nevertheless, the presence of these congestion signs, commonly together with irresponsible management and disincentives to efficiency, can be related to a political interference, labour problems and/or low disposability to expand. These aspects constitute some factors that can constrain very much the provision of hospital services and should be considered in the efficiency analysis and in the strategy for the improvement of economic efficiency and quality of service and mainly the value for money of hospital services.

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