Measuring the efficiency of Greek Public Hospitals compared to Private Hospitals listed on the Athens Stock Exchange using Data Envelopment Analysis (D.E.A).

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Abstract

This study aims to demonstrate the degree of effectiveness, of public teaching hospitals, in the use and allocation of production factors, in comparison with public general and private hospitals. Data Envelopment Analysis was employed with included inputs being (a) the number of beds, (b) the number of employed physicians, (c) the number of employed nursing staff, (d) the number of administrative employees, (e) the total cost for goods and services and (f) the total cost per hospitalized patient, whereas as an output the total number of hospitalized patients was used. This study evaluates the degree of rational use of inputs for a total of 25 Greek (public and private) hospitals for the period 2009-2012 showing a comparative analysis in terms of technical efficiency and scale efficiency. The results show a significant improvement in overall technical efficiency and scale efficiency for the teaching and general public hospitals over private ones. It appears that the significant adjustment imposed in the quantity of production factors (inputs) of the public hospitals, has considerably improved the efficiency levels in contrast to private hospitals for which the change of the mixture and the reallocation of production factors considered to be of great importance. The results for all hospitals of the sample indicate margins for further improvement of their effectiveness by focusing in reduction of their total expenditures.

Keywords: Technical Efficiency; Pure technical efficiency, Scale Efficiency, Hospitals; Data Envelopment Analysis

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1. Introduction

The establishment of a rational, but yet effective national health system, is a priority for every organized state. However, due to the particularities of each society, rooted in historical, social, political, economic, cultural and geographical reasons, the preparation and implementation of a system with such features, is a complex and perpetual process, which constantly need to change due to national and international conjunctures. A health system must retain the basic features of its inception, but it has to be easily adapted, in order to be able to monitor and incorporate the rapid changes occurring in fields of technology, research and in socioeconomic level. In order these changes to be incorporated as quickly as possible in national health systems, not only cooperation between individual countries at international level should take place, but also a common policy on health.

Greece as a member of the European Union makes systematic efforts in order to improve and enhance the quality of health services. In recent decades, several legislative regulations have been developed and implemented, which were designed to reform the national health system, to provide free health services for the entire population, to establish the legal context for the operation of hospitals, whether they are public or private and finally to recruit health facilities with specialized medical and nursing staff.

2. Public Expenditure on Health in Greece

Regarding the current situation of health provision in Greece, the following conclusions can be derived: Since the first quantifiable data available for Greece (1987), the total expenditure on health per capita through 2009 shows a continuous rise, with the percentage change in 2009 compared to 2000 amounting to about 114% and the weighted annual change average for the period 2000-2010 to be around 7.5%. In 2000, total expenditure amounted to $1.451 per capita, while in 2009 it reached $3.106 per capita. In year 2010, and for the first time since 1987, the total expenditure on health per capita showed a downward trend and decline compared to that of 2009 by 6.20% or in numerical terms from $3.106 to $2.914 respectively. This decrease was mainly the result of the drastic cuts in public spending on health, decided by the Greek Government, in an attempt to reduce the large budget deficit. Most of the reductions in public expenditure on health, achieved through adjustments in wage costs, by adjusting the number of employees of hospitals, as well as in procurement costs

Among the 35 countries classified by the OECD, based on the total health expenditure per capita, Greece is in the 22nd place, spending more money than countries such as Portugal, the Czech Republic, Slovenia, Mexico, etc. Specifically, Greece ranks below the average of OECD countries with respect to health expenditure per capita attaining the level of $2.914 in 2010 (adjusted for purchasing power parity), considerably less than the average level of OECD countries, which amounts to $3.268 for the same year. Total expenditure on health in Greece, expressed as a percentage of Gross Domestic Product (G.D.P) for the year 2010 amounted to 10.2 % of G.D.P, higher than the average of OECD countries (9.5%), significantly lower although at national level, as in year 2009 amounted to 10.6% of G.D.P. More specifically, for the period 2000-2010, the annual percentage change in total expenditure on health in Greece is constantly positive, with the notable exception of the year 2010 which shows a decrease of 3.8%, drifting from the decline in G.D.P of Greece, due to the economic crisis, around 4.9 %.

Public spending as a percentage of total expenditure on health in Greece, for the decade 2000-2010, ranged close to 60%, with the weighted average annual percentage change for the same period calculated at -0.1%. In the year 2010 this percentage amounted to 59.4%, significantly lower than that of 2009 (61.7%). In addition, public sector involvement in Greece, in financing the health sector, compared with the average of the expenditure of the member countries of the European Union (EU) for the year 2010, was significantly lower (59.4% Greece versus 77.4% countries of the EU, with the same conclusion to be derived after the comparison with the average of OECD countries for the year 2010, which amounted to 72.2%. It should be noted that the public sector remains the main source of funding the health sector, for almost all OECD countries, with the only exceptions being Chile, Mexico and the United States, where the public sector holds 48.2%. Finally, it should be noted that for the period 2000-2010, public health expenditure in Greece, averaged at 6% of G.D.P and at 12.4% of the total general costs of the government of the country.

3. Private Expenditure on Health in Greece

Private sector in Greece plays an important role in providing health services. Based on available statistics, the number of Greek citizens (especially until 2009 before the current economic crisis fully immersed), visiting private hospitals seeking health care, was continually increasing.

The percentage of private expenditure on health as a percentage of total health expenditure for the period 1995-2011, on average, amounted to 41.2%. More specifically, in the year 1995 it amounted to 48.0% and maintained at the same level for the next 3-4 years. Significant deceleration in private spending was observed from 2000 onwards, when private spending accounted for 40% of total expenditure, maintaining this rate at the same level for the next ten years, i.e. until 2010. In the year 2011 with the Greek economy undergoing the first years of recession, private health spending, has been significantly reduced with the percentage change for the period 2010-2011 exceeds 15%, while for the period 1995-2011 the decline exceeds 32%. The total private health expenditure in the year 2011 for Greece, corresponded to 32.6% of the total health expenditure, ranking Greece between the highest positions (10^{th} position) among OECD countries (average 27.7%). This significant deviation indicates the dynamic of the private sector and underlines the chronic operational problems presented by the N.H.S in Greece.

4. Background on efficiency and its measurement

Integrated and effective provision of healthcare services has always been subject of study and analysis, given the considerable number of production factors and the financial resources requires, in conjunction with the significant role it plays in the proper functioning of a society. Moreover, major changes and reforms that have promoted in recent years throughout the world, under the requisition of international organizations, to ensure equitable access for all citizens in health care, but also the need for significant capital investment in research and technology, prove without a doubt, the efforts of individual governments to change the mix of inputs available for the provision of health services, in order to achieve better results and significantly improve medical and hospital care indicators.

The concept of Efficiency is inextricably linked to achieving objectives. Each economic entity from the beginning of its activity sets some objectives. The level of attainment of these objectives by the end of the production process forms the basis for

conclusions, regarding its Efficiency. The best method for evaluating a single service or a health care system as a hall, is through the use of measurements of direct health outcomes (morbidity, mortality, quality of life, etc.), with the disadvantage of this particular method to be the impractical use observed in many cases. Therefore, the effectiveness of a health service is often measured indirectly by measuring the effectiveness of individual medical and health programs, or the quality and quantity of intermediate procedures (e.g. surgical operations, laboratory tests, etc.) in extent that these are measurements of the final outcomes in health [30].

According to Farell [11], the production efficiency is divided into two sub-levels: (a) Technical Efficiency and (b) Allocative Efficiency or effectiveness of distribution (Cost Efficiency). These two elements constitute the overall efficiency. In recent years, a number of methods to estimate the potential limits of production technology have been developed. These methods are separated into two main categories: (a) parametric or econometric and (b) non-parametric or linear programming. The parametric approaches, use econometric techniques to estimate the limit of production technology (Stochastic Frontier), while non-parametric approaches, use linear programming techniques to estimate the threshold (Data Envelopment Analysis - DEA). The method of DEA, developed by Charnes, Cooper & Rhodes [5], is based on linear programming and does not require a specific functional relationship between inputs and outputs. The important advantage of the DEA method is that it can manage between multiple inputs and outputs without setting in advance weighting factors to them, addressing this way the weaknesses in the analysis of indicators using econometric models. In DEA units that convert inputs into outputs are referred as Decision Making Units (DMU's) [5]. The purpose of DEA is to measure the relative effectiveness between a number of DMU’s, comparing each DMU with the DMU’s of the sample that are fully efficient.

4.1 Efficiency measurement of Greek N.H.S

The majority of the efficiency studies involving the Greek health care sector, using non-parametric and parametric methods, lead to a common conclusion that there is potential for considerable improvement regarding both technical and scale efficiency.
Specifically, Athanasopoulos et al [3], in order to determine the level of technical efficiency as a respect of inputs, used data for the year 1992 for 98 public general hospitals. Estimating the empirical model with the DEA method and distinguishing hospitals by their location (urban, rural), showed a particularly low cost-efficiency (72%-73%) for hospitals located in rural areas. The results were exactly the opposite, in terms of production efficiency, as this category of hospitals showed production efficiency 86%, significantly higher than that of urban hospitals (67%-79%). With this study, Athanasopoulos et al [3] concluded that any inefficiency or any low efficiency are the result of misuse and bad management of financial resources and not due to lack of medical and other personnel. Giokas [13], using both parametric and non-parametric models, measured the degree of technical efficiency for 91 hospitals in the 1992, adopting constant returns to scale. The average technical efficiency was measured separately for general hospitals and separately for the teaching hospitals of the sample. According to the study results, general hospitals had significantly lower technical efficiency in relation to the teaching ones, since for the general hospitals the efficiency was measured at 75.1%, while for teaching hospitals it was measured at 84.7%. Athanasopoulos et al [4], in their new study on the same sample of 98 hospitals, measured the extent and distribution of technical efficiency with the use of a non - parametric model DEA, assuming variable returns to scale. According to study

results, the average technical efficiency was measured between 81%-86% for the whole sample, indicating low utilization of human personnel in hospitals of small and medium size. Zavras et al [32], in their research for 133 health IKA centers, for the period 1998-1999, estimated the technical efficiency between 66%-81.2%. Kontodimopoulos et al [15], estimating a non- parametric model with the DEA method, using data from 2001 and a sample of 90 hospitals, showed that technical efficiency for the entire sample was between 68.4%-73.1%. When there was segregation of hospitals in public and private, the average degree of technical efficiency estimated for the public hospitals at 69% while for private estimated at 86.6%. Kontodimopoulos & Niakas [16], estimating a non-parametric DEA model, using data from 73 dissolution blood laboratories in Greece for the period 1993-2004, measured the degree of technical efficiency ranged between 39.6%-63.1% (average technical efficiency 56.7%) while a new survey conducted by Kontodimopoulos et al [19] involved 124 dissolution blood laboratories for the year 2004, the average technical efficiency was measured at 68.2 % showing a clear improvement over the past. In a study involving 194 hospitals of the N.H.S and IKA conducted by Kontodimopoulos et al [18] showed that IKA hospitals had a higher degree of efficiency, in terms of technical and scale efficiency. Specifically, IKA hospital units recorded an average technical efficiency of 84.9% (versus 70.1% of N.H.S hospital units) and an average scale efficiency of 89.7 % (versus 85.9 % of hospitals N.H.S). Aletras et al. [1], estimating a DEA model using data from 51 Greek hospitals for the years 2000 and 2003, demonstrated higher technical efficiency in 2000 (80.7%) compared with 2003 (70.1%). The same conclusion was reached, with respect to the average scale efficiency, as for the year 2000 the average scale efficiency amounted to 93.2 % while for the year 2003 amounted to 84.9 %. In a survey on the extent of technical efficiency in 27 small and medium N.H.S hospitals [12], the estimation of a non- parametric DEA model for the year 2005, showed a very high effectiveness rate for these hospitals under the assumption of constant and variable returns to scale. More specifically, the average technical efficiency for the entire sample under constant returns to scale was 86.8% while the average technical efficiency for the entire sample under variable returns to scale was 91.4 %. The average efficiency for the entire range of the sample was 94.6%. Androutsou et al [2] estimating a non-parametric DEA model measured the average technical efficiency of 7 clinics for the period 2000-2006. According to the study results, the average technical efficiency was 93.5% for the whole sample. Finally Dimas et al [8], using DEA method measured the average technical efficiency for the period 2003-2005 and data from 22 Greek public hospitals. The empirical results of the study show that the average technical efficiency is declining over the years, as in 2003 it was measured at 86.5%, in 2004 it was measured at 84.5% and in 2005 it was measured at 82.5%.

5. Data and methods

5.1 Sample and data collection

The primary statistics used in the quantitative and empirical analysis of this study, relate to public hospitals (teaching, general), as well as private hospitals which offer healthcare services in almost all the Greek territory. The majority of the data in all hospital units of the research relate to the period 2009-2012[3]. The present study was based on statistics, which are published in the Annual Reports of the Ministry of Health (2010 & 2011), posted on the Greek Health Map, or obtained from the

[3] There was no available data for the year 2012 for the private hospitals

Ministry of Health. The previews data relate mainly to Public hospital units, while as far as the Private Hospital units are concerned, the majority of the data is drawn from the official websites of these units, the annual financial statements, the corporate presentations and the hospitals themselves directly. Supporting role in this effort played the data drawn from the Greek Statistical Authority (EL.STAT), as well as from international organizations, such as OECD, the World Bank and the European Statistical System (Eurostat).
The hospitals of the sample were selected based on the following conditions: public hospitals are either teaching or general. Selected private hospitals are enlisted on the Athens Stock Exchange. The hospital units are "large", with the number of beds exceeding 400 (>400). Finally hospitals that are specialized in a certain field of hospitalization (e.g. Children care, Anticancer, Oncology, Psychiatric, etc.) were excluded from the sample.

5.2 DEA model specification

The estimation of DEA models will be applied with orientation to inputs which focuses on reducing the amount of used production factors in order hospitals to achieve higher efficiency levels. The input-oriented model focuses on the minimization of inputs and calculates the degree to which each hospital of the sample can reduce the quantities of utilized inputs in order to still produce a given amount of outputs. Moreover, the initial model of Charnes et al [5] made the dubious assumption of Constant Returns to Scale (CRS). Subsequently, the model was further developed to measure technical efficiency under Variable Returns to Scale (VRS). In this paper the model of DEA, will be assessed for both constant and variable returns to scale.

Due to limited availability of data for the year 2009 the following were used as inputs: (a) the number of beds and (b) the total cost for goods and services. The total number of hospitalized patients was used as an output. In years 2010 and 2011 in order to estimate the DEA model the following were used as inputs: (a) the number of beds, (b) the number of employed physicians, (c) the number of the employed nursing staff, (d) the number of administrative employees, (e) the total cost for goods and services, and (f) the total cost per hospitalized patient. In both cases as an output the total number of hospitalized patients was used. Finally in the year 2012, DEA model was estimated only for the public hospitals, due to the lack of data for private hospitals.

6. Empirical results

Technical efficiency statistics and hospital rankings relative to years 2009-2012 are presented in Table 1. Tables 2, 3 and 4 present the results of the total technical efficiency (CRS), the pure technical efficiency (VRS) and scale efficiency (Scale Efficiency) by type of hospital unit. The average total technical efficiency for the period 2009-2012, under the assumption of constant returns to scale (CRS), rise from 75.2% to 85.3% for all 25 hospital units. The estimation of the DEA model under the assumption of variable returns to scale (VRS), which seems to reflect more correctly the process of hospital production, has demonstrated also an increase in the pure technical efficiency of hospitals from 2009- 2012, from 85.2% to 93.2%. The different assessment to the extent of efficiencies between constant and variable returns to scale (10.1% CRS - 8% VRS) shows that inefficiencies actually exist in the hospital production as a result of the prevailing type of returns to scale (increasing or decreasing).

Table 1
Technical efficiency statistics and hospital rankings

Descriptive Statistics	2009		2010		2011		2012	
	CRS Model	VRS Model	CRS Model	VRS Model	CRS Model	VRS Model	CRS Model	VRS Model
N	25	25	25	25	25	25	22	22
Arithetic Mean	75,2%	85,2%	82,3%	90,8%	83,7%	92,7%	85,3%	93,2%
S.D	17,1%	15,9%	15,4%	12,8%	15,9%	12,3%	16,3%	9,5%
Minimun	42,8%	45,1%	47,0%	52,1%	47,7%	54,8%	53,4%	68,5%
Maximum	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Hospital Ranking	2009		2010		2011		2012	
	CRS Model	VRS Model	CRS Model	VRS Model	CRS Model	VRS Model	CRS Model	VRS Model
100%	3 (12.0%)	5 (20.0%)	4 (16.0%)	11 (44.0%)	8 (32.0%)	16 (64.0%)	9 (40.9%)	11 (50.0%)
90-99,9%	1 (4.0%)	8 (32.0%)	6 (24.0%)	5 (20.0%)	2 (8.0%)	1 (4.0%)	1 (4.5%)	3 (13.6%)
80-89,9%	6 (24.0%)	6 (24.0%)	6 (24.0%)	4 (16.0%)	7 (28.0%)	5 (20.0%)	6 (27.3%)	5 (22.7%)
70-79,9%	7 (28.0%)	2 (8.0%)	5 (20.0%)	3 (12.0%)	3 (12.0%)	1 (4.0%)	1 (4.5%)	2 (9.1%)
60-69,9%	3 (12.0%)	1 (4.0%)	2 (8.0%)	1 (4.0%)	2 (8.0%)	1 (4.0%)	2 (9.1%)	1 (4.5%)
50-59,9%	2 (8.0%)	1 (4.0%)	0 (0.0%)	1 (4.0%)	2 (8.0%)	1 (4.0%)	3 (13.6%)	0 (0.0%)
40-49,9%	3 (12.0%)	2 (8.0%)	2 (8.0%)	0 (0.0%)	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
<40%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Descriptive Statistics	2009	2010	2011	2012
	Scale Efficiency	Scale Efficiency	Scale Efficiency	Scale Efficiency
N	25	25	25	22
Arithetic Mean	88,5%	90,7%	90,4%	91,6%
S.D	12,3%	11,5%	12,2%	14,5%
Minimun	60,0%	63,6%	58,7%	53,4%
Maximum	100,0%	100,0%	100,0%	100,0%

Table 2
Technical efficiency statistics and General hospital rankings

Descriptive Statistics	2009			2010			2011			2012		
	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency
N	14	14	14	14	14	14	14	14	14	14	14	14
Arithetic Mean	73,9%	86,1%	85,8%	79,2%	91,0%	87,2%	83,4%	94,6%	88,3%	81,1%	92,7%	87,6%
S.D	15,0%	13,2%	12,5%	16,8%	14,2%	13,2%	14,3%	10,9%	11,9%	18,2%	10,3%	17,0%
Minimun	44,0%	58,1%	60,0%	47,0%	52,1%	63,5%	56,8%	65,1%	64,3%	53,4%	68,5%	53,4%
Maximum	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Hospital Ranking	2009			2010			2011			2012		
	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency
100%	1 (7.1%)	2 (14.3%)	1 (7.1%)	2 (14.3%)	7 (50.0%)	2 (14.3%)	4 (28.6%)	10 (71.4%)	4 (28.6%)	5 (35.7%)	7 (50.0%)	5 (35.7%)
90-99,9%	0 (0.0%)	5 (35.7%)	6 (42.9%)	3 (21.4%)	3 (21.4%)	6 (42.9%)	1 (7.1%)	1 (7.1%)	3 (21.4%)	0 (0.0%)	2 (14.3%)	4 (28.6%)
80-89,9%	3 (21.4%)	3 (21.4%)	2 (14.3%)	2 (14.3%)	1 (7.1%)	1 (7.1%)	5 (35.7%)	1 (7.1%)	4 (28.6%)	4 (28.6%)	3 (21.4%)	1 (7.1%)
70-79,9%	5 (35.7%)	2 (14.3%)	3 (21.4%)	5 (35.7%)	2 (14.3%)	4 (28.6%)	2 (14.3%)	1 (7.1%)	2 (14.3%)	0 (0.0%)	1 (7.1%)	2 (14.3%)
60-69,9%	3 (21.4%)	1 (7.1%)	2 (14.3%)	0 (0.0%)	0 (0.0%)	1 (7.1%)	2 (14.3%)	1 (7.1%)	1 (7.1%)	2 (14.3%)	1 (7.1%)	2 (14.3%)
50-59,9%	1 (7.1%)	1 (7.1%)	0 (0.0%)	0 (0.0%)	1 (7.1%)	0 (0.0%)	1 (7.1%)	0 (0.0%)	0 (0.0%)	3 (21.4%)	0 (0.0%)	0 (0.0%)
40-49,9%	1 (7.1%)	0 (0.0%)	0 (0.0%)	2 (14.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
<40%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

According to DEA estimations, the number of hospitals, regarded as “excellent” in terms of efficiency, has increased significantly during the period from 2009-2012, for both CRS and VRS models. Specifically for CRS model, the number of “reference” (excellent) hospital units from a total of 3 in 2009, increased to 9 for the year 2012. Similarly for VRS model, the specific number of hospitals reached 5 for 2009 and 11 in year 2012. It is obvious that if the hospitals had adopted the production processes of "excellent" in terms of efficiency units, they could have produced the same level of hospital output, with a significantly lower amount of inputs. Specifically, in the year 2009 and under variable returns to scale, the same hospital output could have been produced by reducing the total amount of inputs on average by 14.8%, in 2010 by 9.2%, in 2011 by 7.3% and finally in 2012 by 6.8%. Under the assumption of constant returns to scale, the equivalent on average decrease in the quantity of inputs amounts to 24.8% in 2009, to 17.7% in 2010, to 16.7% in 2011 and 14 7% in 2012.

Regarding Scale Efficiency (Table 1), it increased from 88.5% on average in 2009 to 91.6% in 2012, indicating a significant improvement, which could be due to both significant average reductions of beds of hospital units and to the significant average increase in total patients which suggests an increase in the volume of activities of hospitals.

Table 3
Technical efficiency statistics and Teaching hospital rankings

Descriptive Statistics	2009			2010			2011			2012		
	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency
N	8	8	8	8	8	8	8	8	8	8	8	8
Arithetic Mean	87,3%	92,1%	94,8%	87,7%	92,7%	94,4%	93,2%	94,4%	98,6%	92,6%	94,1%	98,5%
S.D	10,1%	7,4%	7,0%	13,4%	9,8%	8,3%	9,4%	7,7%	3,4%	9,0%	8,6%	3,0%
Minimun	73,2%	82,2%	79,3%	61,3%	76,4%	80,3%	77,7%	83,5%	90,2%	75,8%	78,4%	91,5%
Maximum	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Hospital Ranking	2009			2010			2011			2012		
	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency
100%	2 (25.0%)	3 (37.5%)	2 (25.0%)	2 (25.0%)	3 (37.5%)	2 (25.0%)	4 (50.0%)	5 (62.5%)	4 (50.0%)	4 (50.0%)	4 (50.0%)	5 (62.5%)
90-99,9%	1 (12.5%)	2 (25.0%)	5 (62.5%)	2 (25.0%)	2 (25.0%)	4 (50.0%)	1 (12.5%)	3 (37.5%)	4 (50.0%)	1 (12.5%)	1 (12.5%)	3 (37.5%)
80-89,9%	3 (37.5%)	3 (37.5%)	0 (0.0%)	3 (37.5%)	2 (25.0%)	2 (25.0%)	2 (25.0%)	0 (0.0%)	0 (0.0%)	2 (25.0%)	2 (25.0%)	0 (0.0%)
70-79,9%	2 (25.0%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	1 (12.5%)	0 (0.0%)
60-69,9%	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
50-59,9%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
40-49,9%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
<40%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 4
Technical efficiency statistics and Private hospital rankings

Descriptive Statistics	2009			2010			2011		
	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency
N	3	3	3	3	3	3	3	3	3
Arithetic Mean	49,2%	63,0%	83,8%	82,0%	84,9%	97,0%	59,8%	78,9%	78,3%
S.D	7,9%	27,7%	19,6%	13,6%	16,4%	4,0%	12,6%	22,7%	17,0%
Minimun	42,8%	45,1%	61,1%	66,7%	67,5%	92,4%	47,7%	54,8%	58,7%
Maximum	58,0%	94,9%	95,2%	92,4%	100,0%	99,7%	72,9%	100,0%	89,0%

Hospital Ranking	2009			2010			2011		
	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency	CRS Model	VRS Model	Scale Efficiency
100%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)
90-99,9%	0 (0.0%)	1 (33.3%)	2 (66.7%)	1 (33.3%)	0 (0.0%)	3 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
80-89,9%	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	2 (66.7%)
70-79,9%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)
60-69,9%	0 (0.0%)	0 (0.0%)	1 (33.3%)	1 (33.3%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
50-59,9%	1 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	1 (33.3%)	1 (33.3%)
40-49,9%	2 (66.7%)	2 (66.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)
<40%	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

In order to achieve a performance comparison between public and private hospitals (Tables 2, 3 and 4) the estimates on the effectiveness of hospital units and the scale production have been reclassified. Based on the estimates, public general hospitals of the sample under constant returns to scale showed an overall efficiency of 73.9% to 83.4%. Under variable returns to scale, the level of efficiency was estimated between 86.1% and 94.6%, while the scale efficiency was estimated between 85.8% and 88.3% on average. Regarding public teaching hospital units, DEA estimations concerning the level of efficiency under constant returns to scale estimated from 87.3% to 93.2% on average and under variable returns to scale estimated from 93.1 % to 94 4%, while the estimated scale efficiency was estimated between 94.1% to 98.6% accordingly. Private's hospital units effectiveness under constant returns to scale, estimated between 49.2% and 82.0% on average, whereas for variable returns to scale

their effectiveness estimated between 63.0% and 84.9%, and scale efficiency estimated between 83.8% and 97%. According to the above results it is obvious that public hospital units for the period of this study showed significant improvement in their effectiveness, as opposed to private hospital units. It is obvious that the intense fiscal adjustment that was applied in public hospitals had a significantly positive affect at the overall level of effectiveness of those units, while in contrast, private hospitals seem to be unable to adapt to new economic conditions created by the economic recession showing a significant degree of inefficiency.

7. Discussion

The aim of this study is to measure the degree of effectiveness of 25 hospital units which operate in the Greek dominion. According to the empirical results, there is a significant variation in efficiency levels between public and private hospitals, which indicates the need for adjusting the mix of production factors. The estimation of the DEA model, with emphasis on reducing inputs, can be the starting point for the administration of the units, so as to derive information and identify quantities of abeyance production factors, in order to change the production mix and achieve more optimal levels of efficiency. It is evident that hospitals should take measures to reduce the amount of certain production factors used, giving particular emphasis to further reduce of their total cost.

According to DEA results, teaching hospitals units' exhibit greater level of effectiveness compared to both public general hospital units and private ones. Teaching hospitals show a continuous increase in the number of fully efficient units (Overall Technical Efficiency 100%, Table 3) for all the period examined in this study, utilizing their productive factors above 80%. Equally important is the rise of the efficiency level of the public general hospitals, as these units recorded a continuous increase in the number of units that utilize fully and efficiently their production factors (Table 2). The overall technical efficiency for private hospitals shows that none of these units have managed to use fully and efficiently their production factors. This discrepancy is most likely attributed to different practices of financial management among public and private units. The fiscal and economic adjustment applied from 2009 in the organization and administration of public hospitals seems to have positive effect in terms of efficiency for these units. The significant reduction of the total cost, and the adjustment of the number of employees (medical, nursing, administrative, etc.) with the simultaneous movement of a significant number of patients from private to public sector, have significantly improved the level of effectiveness of public hospitals. Private hospitals, despite the greater flexibility available regarding level decisions and changing the mix of inputs, show significant weaknesses to adjust their services in short term. Significant capital investments particularly after 2000 in new technologies, human resources, capital equipment and the continued expansion of hospital network services have contributed to the expansion of both production and operating costs of these units. It is clear that in the short term private hospital units seem unable to adapt to their production process, both in terms of size, as well as the mix of production factors. Negative impact on the degree of their efficiency, has also played the reduced demand for private health services, mainly as the result of the significant reduction in the disposable income of Greek households. Based on the estimation of DEA model, public general hospital units, for the period 2009-2012 can produce exactly the same hospital output, reducing their production inputs on average by 20%, Teaching Hospital Units by 10% and Private Hospital Units by 35%.

Measuring the efficiency of hospitals by extension as well, the degree of utilization of their production factors is a process which should always be treated with extreme caution and always in the light of the complexity that enhances. From the introduction of the N.H.S until today, the main "question" of how to impose a cutback on spending on health, without under any circumstances affecting the level of health services needs to be answered. The factors that compose a complete health system are numerous, having different weights for different health systems. Many of these factors are very difficult to be determined, and if finally they are determined it is very difficult to measure the percentage of their contribution in the production process. In this study, an attempt was made to measure the overall effectiveness of 25hospitals, public and private. The results showed significant differences in the degree of efficiency between public and private units, with public units to record significantly higher degree of efficiency over private. For all hospital units of the sample, inefficiencies were highlighted, amounts of production factors that are not been used were detected and wrong choice of model administration was noted. Improving the efficiency and the degree of rational use of production inputs, require significant variations both at management level and at the degree of utilization of inputs. Private hospitals have to improve their level of efficiency by changing significantly the way they operate in order to cover the difference between the supply and demand for private health services. This can be achieved, for example, either by significant downward adjustments in the pricing policy or in long term through mergers and restriction of private healthcare services sector. Public hospital units, have for the first time in their long history, to cope with the increased demand for medical and hospital services, through better use and utilization of production factors and not by increasing their costs, as current socioeconomic conditions do not favor this. The significant readjustment which was recorded between 2009- 2012, in both expenditure and human resources, seems to positively affect the degree of effectiveness of these units, but further reduction can lead to diametrically opposite results from the desired ones.

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