Evaluating the technical and scale efficiency of the large hospitals in Greece

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Abstract— The aim of this study is to assess the performance of the large hospitals in Greece. More specifically, we measure how well the Greek public Hospitals use their resources, to serve as much as possible patients. We apply the method of Data Envelopment Analysis, to assess the efficiency of 24 large hospitals during the years 2009 to 2012. The input variables were the number of physicians, the number of nurses and other personnel, and expenditures of every hospital. The output variables were the number of inpatient admissions and the number of outpatient visits. The study identifies the inefficient hospitals and provides the magnitudes of specific input reductions or output increases needed to attain technical and scale efficiency. The analysis indicates that the overall efficiency has improved during the study period. The pure technical inefficiency (i.e., managerial inefficiency) is the main source of technical inefficiency while, the contribution of scale inefficiency has been observed to be smaller. The main finding of this paper is the need for better resource allocation in the Greek national health system, because some hospitals have resource surplus and in other hospitals it is observed a lack of resources.

Keywords— Data Envelopment Analysis, Linear programming, Efficiency, Greek hospital performance.

I. INTRODUCTION

THE management of the health services are one of the most significant aspects of the public administration, since the health level of the population is a determinant for the economic growth and the social development. In addition, it is a discernible relation between the investments in public health care system, the improvement in living standard and the economic growth. Also, the improvement in health condition of a population increases the productivity, the income per capita and expands the period that a worker could be productive. Finally, a healthy population can improve the social well-being, the macroeconomic stability through the increase in tax income and the decrease in the public expenditures for the health system.

The resource allocation in health care units is now more important than ever. The outbreak of the recent economic crisis, has led to tightening public budgets. The austerity programs were implemented, as well, in healthcare and mainly focused in the hospital sector that comprises the majority of public total healthcare spending. Pressures for sector reform have stimulated interest in identifying and understanding the factors that can contribute to improve the hospital's performance. In order to elevate the consequences of the recession the governments should allocate the resources in a way that minimize the expenditures while maximizing patient safety.

The Public hospitals’ expenses reached EUR 2.6 billion in 2010, decreased by EUR 500 million by the end of 2012 [1]. Although Greek hospitals are considered to be a public service with no profit goal, they still try to minimize costs by changing input allocation in order to maximize production and comply with the given budget. On the other hand, patients who previously used the private sector turned to the public sector, automatically increasing the public sector's spending during the economic downturn. The question is to what extent is the austerity related to increased productivity.

Data envelopment analysis (DEA) is a comparative evaluation method, based on linear programming, for measuring the relative efficiencies of a homogenous set of decision making units. DEA is receiving increasing importance as a tool for evaluating and improving the service operations [2].

Data envelopment analysis has been used extensively to address relative efficiency assessments in public sector activities with increased degree of complexity in recent years. Since the introduction of DEA methodology, a considerable number of researchers have applied DEA in evaluating the efficiency of different healthcare organizations. Several systematic reviews of health efficiency studies have been conducted over the last few years [2,3]. However, the majority of the reviewed studies are in the hospitals sector, reflecting its central role in the health care system. All of these above mentioned studies provide information about the growth of this research body and discussing the reliability of efficiency estimates, upon which relevant policy decisions were drawn. These studies also offer extensive overviews of the literature and some in-depth discussion on DEA’s applicability, strengths and limitations.

DEA is a linear programming technique, developed by Charnes, Cooper, and Rhodes [4], for estimating the relative efficiency of a homogeneous set of production units by considering multiple input and output factors. In the input-orientated case, the DEA method holds outputs constant and
seeks to identify inefficiency as a proportionate decrease in input production.

A hospital employs its resources (human, financial, and capital) to produce health care services. A basic economic problem is how to avoid waste in that process. Since the health care managers have more control over the utilization of resources rather than over the arriving patients either for outpatient visit or admissions, it is more appropriate to assume that an input-oriented DEA model should be adopted. We assume that there are \( n \) hospitals to be evaluated. DEA constant returns to scale (CRS) model considers the following optimization problem to determine relative efficiency of \( r_0 \) hospital among \( R \) units.

\[
\begin{align*}
\min \theta \\
s.t. \quad & \sum_r X_{ir} \lambda_r - \theta X_{ir} \leq 0 \quad i = 1, \ldots, I \\
& \sum_r Y_{jr} \lambda_r - Y_{jr0} \geq 0 \quad j = 1, \ldots, J \\
& \varphi \lambda_r \geq 0, \quad r = 1, \ldots, R
\end{align*}
\] (1)

Where \( \theta \) is the radial output contraction factor measuring the level of efficiency for the \( r_0 \) hospital, \( Y_{jr} \) is the amount of the \( j \)-th output produced by \( r \)-th unit, \( X_{ir} \) is the amount of the \( i \)-th input produced by \( r \)-th hospital and \( \lambda_r \) is the non-negative input/output weights that determine the best practice for the hospital being evaluated.

The variable returns to scale (VRS) model is obtained by simply adding the convexity constraint \( \sum \lambda_r = 1 \) to the above linear program.

Finally the scale efficiency score for each hospital was obtained by dividing the CRS efficiency score by the VRS efficiency score. A scale efficiency score of one implies that the hospital in question is operating at optimal scale or size. If the scale efficiency score is less than one, then the hospital is either too big or too small relative to its optimal size.

### II. DATA AND SAMPLE

The present study has been based on data provided by the Greek Ministry of Health concerning 24 large hospitals for the years 2009 to 2013. The total number of Greek public hospitals is 134. In the original data set, hospital sizes range from 18 to 936 beds. However, hospitals with different sizes usually have different characteristics in terms of economies of scale, market share and access to advanced technologies [5].

In order to control the differences in size and make the samples more homogeneous, we select 24 hospitals with more than 250 beds for analysis. Considering the different operation characteristics of hospitals we can categorize them as university and non university hospitals with 7 and 17 units assigned to each group, respectively.

In this study the selection of input/output variables was designed according to the previous studies in the literature [5,6]. The input variables chosen for our analysis are: (1) the number of doctors; (2) the number of other personnel (which includes nurses, administrative and support staff); and (3) total operating cost (excluding the payroll expenses). The output variables consist of: (1) the number outpatient visits; and (2) the number of inpatient admissions. The sample means and standard deviation of the inputs/outputs that used in the analysis are presented in Table 1.

### III. RESULTS AND DISCUSSION

We observe that all type of efficiencies have improved during the study period. The average CRS efficiency increased by 4% from 0.82 in 2009 to 0.86 in 2013. The average VRS efficiency was also increased 3% and at the same time the hospitals scale efficiency increased slightly by 1%.

We further examine the efficiency differences observed during the study period using nonparametric statistical procedures. The Friedman test for dependent samples is employed to test the hypothesis of no difference in efficiency scores obtained from 2009 to 2013 in each type of efficiency. The results of the Friedman test specify significant differences in CRS and scale efficiencies (with p-values of 0.001 and 0.0006 respectively) while the VRS differences were insignificant at any confidence level. Therefore, the observed differences in scale efficiencies of hospitals are based mostly to the deviations of the pure technical efficiency. Using again the Friedman test the differences in the efficiency scores between the consecutive years of the study, we observe that a significant change appeared in the period 2010-2011 for the CRS and scale efficiency scores (p-values: 0.007 and 0.0001). In addition the scale efficiency score significantly change in 2012-2013 (p-value=0.003).

The results pertaining to returns-to-scale in Greek hospitals highlight that the predominant form of scale inefficiency is the decreasing returns-to-scale imply that a hospital has an inefficient large size. More specifically, the average number of hospitals with decreasing returns to scale was 10 imply that these hospital has an inefficient large size. To decrease the consequently high unit cost and come back to their optimal

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<td>133</td>
<td>484</td>
<td>113</td>
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<td>121</td>
<td>378</td>
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<td>285</td>
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<td>290</td>
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<td>277</td>
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<td>561.02</td>
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<td>74.151</td>
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<td>1.64655</td>
<td>50.948</td>
<td>174.413</td>
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Table1: Descriptive statistics concerning the hospitals of the study from 2009 to 2013.
scale, such hospitals need to scale down their size (beds and staff). For those hospitals, it might be politically difficult to consider bed closures or decrease in their personnel, but at least they should not keep increasing them. However, because of the non-competitive environment in the health public sector, operating at decreasing returns to scale can be a choice dictated by the demand side.

In contrast, the average number of units with increasing returns to scale was only 2.4. These hospitals have not reached their optimal scale yet, which is mostly observed in small-size hospitals (average inputs below sample average). In the presence of increasing returns to scale, there is still room for expansion of outputs and reduction of unit costs. A hospital with increasing returns to scale will, therefore, benefit from augmenting its scale of operations. However, increasing the level of outputs requires an increase in demand for health, which often is beyond the hospital management’s control.

Comparing the efficiencies between university and non-university hospitals, we observe that the university hospitals perform better in all years of the study period. Regarding the scale efficiencies, it is evident that the university hospitals operate very close to their optimal scale. Hence, the university hospitals operate with full utilization of inputs and optimal scale.

### IV. Conclusion

This study has attempted to assess the technical and scale efficiency of the large Greek public hospitals in the recent time period. The efficiency scores are computed using DEA, which is a non-parametric method used to model the relationship between multiple inputs and outputs for a decision making unit (DMU), it then provides estimates of the potential improvement that can be made in inefficient units, in our case inefficient hospitals.

From our analysis of overall technical efficiency, pure technical efficiency, and scale efficiency, we find that on average, the Greek public hospitals improve their operations during the study period. These figures are good indicators of the total costs that could be saved since technical and scale efficiency are necessary conditions for cost minimization.

### REFERENCES


