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Measuring Across Hospital Efficiency and Productivity: The Case of Second Regional Health Authority of Attica

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Abstract:

The purpose of the study is to investigate technical efficiency and productivity change of a sample of Greek Hospitals over the period 1998 - 2005. Efficiency and productivity measurement became a crucial issue in Greece after the launching of health reforms in 2001, with the legislative Act No. 2889, aiming at cost containment and improvements in hospital efficiency. Applying the linear programming method of Data Envelopment Analysis we investigate how efficiently the hospital resources are used to obtain the maximum possible outcome, before and after the reforms. Hospital output is modelled in terms of interventions, laboratory examinations, outpatient and inpatient cases. Inputs considered include beds, doctors, nurses and rest personnel and operational expenses. The analysis indicates that the reforms have generated efficiency gains when only input and output quantities are considered. During the period 1998-2002 an overall efficiency regress is observed followed by an upturn, after the launching of managerial reforms. However, when the running costs of the hospitals are considered, then the sample experiences significant regress, implying relatively higher production costs over time. We conclude that DEA is a useful technique to assess relative efficiency and optimum hospital performance across hospitals.

Keywords: Hospital efficiency, productivity, health.

JEL Classification: I11, I12, I18

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1. Introduction

In most western countries, the costs of health care have shown substantial increases during the last four decades and it is generally expected that in the future this trend will continue. To explain this trend, researchers have tried to identify the impact that factors such as over-insurance, technological change, the ageing population, increased societal expectations, supplier induced demand and the relative price effect may have on the utilisation and costs of health care services.

This list was recently expanded to include efficiency and productivity (Feldstein, 1967; Braeutigam and Daughety, 1983; Breyer, 1987; Carr and Feldstein, 1967; Conrad and Strauss, 1983; Cowing and Holtmann, 1983; Eakin and Kniesner, 1988; Fournier and Mitchell, 1992; Vita, 1990; Bays, 1980; Barnum and Kutzin, 1993; Bilodeau, et al., 2000; Li and Rosenman, 2001). Over the past decade or so there have been a considerable number of studies whose main objective has been to measure and analyse health care services efficiency and productivity. In his seminal paper on resource utilisation, Debreau (1951) gave two principal reasons why deviations from optimum performance may occur.

Firstly, market failure and secondly, non-profit maximising firm behaviour, arising from institutional structures that differ from private ownership and individual property rights. Both of these sources of deviation from optimal (efficient) performance exist in the provision of health care services. In short, the demand for health care is a *derived demand* and often it is not desirable, in the sense that individuals consume health care not for its own sake but to improve their health. There is asymmetry of information between the consumer and the provider and this causes phenomena such as *supplier induced demand* and *moral hazard*. (Maniadakis and Yfantopoulos, 1996).

The industry is highly regulated and the service consumer is in most cases restricted as to which provider to choose. Finally, health care services are in many cases provided in public institutions where the principal aim of the doctor - the service deliverer - is neither to optimise profit nor to optimise resource utilisation, but to maximise the welfare of the patients treated.

For the above reasons health care institutions are particularly suspect of inefficiency and low productivity. This, in conjunction with financial pressures and an increasing demand for health care, has led recently many western countries to reform and reorganise their health care systems (OECD, 1996; 2007). Often, the main aim of the reforms was to correct for the market failure and to introduce motives that would lead to efficiency and productivity increases in the delivery of services and consequently to restrain health care costs. In 2001, the National Health Service (NHS) in Greece, as dramatically reformed with the introduction of regional health authorities, management and other new institutions within hospitals.

The aim of the reforms as well as those introduced subsequently in 2005 (Act No. 3329) was to make a more efficient and productive health care system. In Greece several studies have been conducted aiming at the assessment of productivity using both parametric (Yfantopoulos, 1980) and non parametric techniques (Athanasopoulos and Gounaris, 2001 and Giokas, 2001). The results have revealed that public hospitals present various levels of inefficiencies attributed to their size, geographical area, and teaching activities.

The aim of the present study is to twofold: a) to measure and analyse the performance of NHS acute hospitals - the main health care providers - over the period 1998-2005 and b) to assess the implementation of reforms aiming at greater hospital efficiency before and after the reforms. The study focuses on sample of acute hospitals at the Second Regional Health Authority of Attica during the period 1998 - 2005.

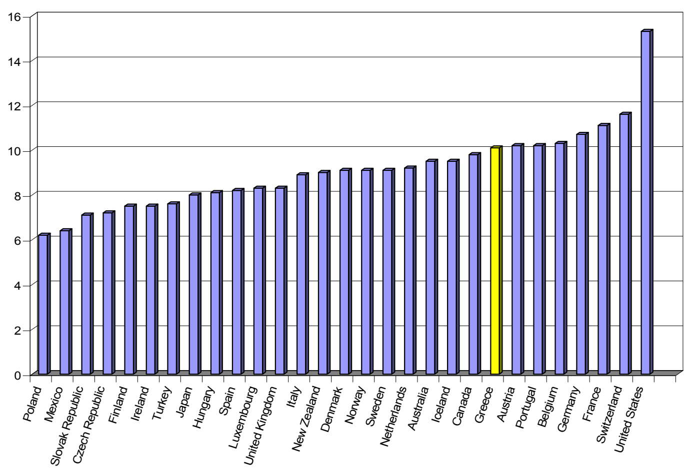
We model the hospital technology of production in terms of input distance functions (Shephard, 1953; 1970) which are the reciprocal of the technical efficiency measure (Farrell, 1953; Färe, R., Grosskopf, S. and C.A.K. Lovell, 1994; Färe and Primont, 1995) and in the empirical context are estimated with non-parametric mathematical programming, known as Data Envelopment Analysis. This approach is used to compute and decompose efficiency over time.

2. Background

Responsible for the national strategy as well as for overall health policy issues, in Greece, is the Ministry of Health and Social Solidarity, which sets priorities at a national level, defines the extent of funding for proposed activities and allocates health resources. In addition to the Ministry, various bodies participate in the governance of the public health care system.

Social Insurance Funds, which provide health coverage, operate under the supervision of the Ministry of Labour and Social Affairs. According to OECD 2005 statistics Greece is classified among the big spenders in health care since 10.1% of the GDP is devoted to total health expenditure. The corresponding average of all OECD countries is 9.0%. (Figure 1).

Figure 1. Health Expenditure as percent of GDP in OECD Countries 2005



Examining the structure of health expenditure, Greece presents an important diversity from the rest of the European Countries because, despite the establishment of a National Health Service in 1983, is the only Country where the proportion of private expenditure is accounting around 57% of total expenditure (OECD, 2007). In terms of public spending, Greece is among the lowest Countries of OECD with only 4.3% of the GDP being devoted to health whereas the corresponding OECD average in 2005 is 6.4%.

At the regional level, the Regional Health Authorities have extensive responsibilities for the coordination of regional activities and the effective organization and management of all health care units within their catchment area. Each Regional Health Authority is a public entity, managed by a General Director appointed by the Minister of Health, subject to parliamentary approval. They maintain close cooperation with the Ministry and the Scientific Council (KESY).

The hospitals and the rest of health care units operate as decentralized and independent units of the Regional Health Authority which they geographically belong. Each health care unit maintains both administrative and financial independence. NHS Hospitals are managed by a Hospital Managing Director and a Board. Public hospitals, operating within the NHS, include 123 General and Specialised hospitals with a total capacity of 36.621 beds and 9 psychiatric hospitals with 3.500 beds. Most of the 123 NHS hospitals provide mainly secondary care services to their constituency and 32 provide tertiary and highly specialised care. Public hospitals are financed through the state budget and social insurance funds.

Public hospitals outside the National Health System include 13 Military hospitals financed by the Ministry of Defence, 5 Hospitals which belong to the main Sickness Fund IKA and two small teaching hospitals operating under the authority of the National Kapodistrian University of Athens. In rural areas 201 Health Centres provide primary health care services and emergency services, short-stay hospitalisation and follow up care for recovering patients, dental treatment, family planning services, preventive health, vaccinations, and health education.

3. Methodology

In this paper productive efficiency is measured by means of Data Envelopment Analysis (DEA). Consider that in time period t hospitals are using inputs $x^t \in \Re_+^n$ to produce outputs $y^t \in \Re_+^m$. Define now the production technology of period t in terms of the *input requirement set*, which is:

$L^t(y^t) = \{x^t: x^t \text{ can produce } y^t\}$,
(1).

$L^t(y^t)$ contains all input vectors that can produce the observed output in any period t.

Assume that $L^t(y^t)$ is non-empty, closed, convex and satisfies strong disposability of inputs and outputs (Färe and Primont, 1995). $L^t(y^t)$ is bounded from below by the input *isoquant,* that is:

$FL^t(y^t) = \{x^t: x^t \in L^t(y^t), \lambda x^t \notin L^t(y^t), \text{ for } \lambda < 1\}$,
(2).

The isoquant defines a *boundary* (*frontier)* to the input set and those input vectors that lie on it are efficient in the sense that any radial reduction to them within $L^t(y^t)$ is not possible. Alternatively, the technology of production can be represented in terms of the *input distance function* (Shephard, 1953; 1970) which with reference to the input set is defined as:

$D_i^t(y^t, x^t) = \sup_{\theta} \{\theta : (x^t/\theta) \in L^t(y^t)\}, \theta > 0\}$,
(3).

The input distance function in (3) computes the largest radial contraction of x^t within $L^t(y^t)$. $D_i^t(y^t, x^t)$ characterises the technology of production completely in the sense that $D_i^t(y^t, x^t) \geq 1$ is sufficient for $x^t \in L^t(y^t)$ and if $D_i^t(y^t, x^t) = 1 \Leftrightarrow x^t \in FL^t(y^t)$. $D_i^t(y^t, x^t)$ is homogeneous in inputs and reciprocal to Farrell's (1957) input measure of *technical efficiency.* Färe and Primont (1995) and Färe, Grosskopf and Lovell (1994) show how it can be decomposed into pure technical and scale efficiency. The function in (3) can easily handle producers with multiple inputs and outputs such as hospitals. It does not impose any behavioural assumption and its empirical measurement requires only input and output quantity data.

The input rather than the output distance function was preferred here because we assume that hospitals have more control over the input they employ rather than the output they produce. This is due to the fact that they must satisfy all the demand for their services and thus it can be argued that output is exogenously determined. For unit k, the single distance function and the efficiency measure defined in (4) can be computed using DEA as follows:

$$\left[D_{ic}^t(y^t, x^t)\right]_k^{-1} = \min_{z,\theta} \quad \theta_k$$

Subject to

$$\sum_{j=1}^{J} z_j y_{jm}^t \geq y_{km}^t$$

$$\sum_{j=1}^{J} z_j x_{jn}^t \leq \theta_k x_{kn}^t$$

$$z_j \geq 0$$

(4),

This model computes efficiency under constant returns to scale, whilst to compute the efficiency under variable returns to scale one simply has to add $\sum_{j=1}^{J} z_j = 1$ to the above model.

4. Framework and Data

The non-parametric mathematical programming approach has been applied to a large amount of diversified fields, including hospital economics, banking and finance, transportation, utilities, public services delivery, military operations etc. Most of these applications were motivated by the need to measure efficiency and to investigate its relation to observable characteristics of efficient organisations. Recently, the application of DEA in hospital settings has attracted considerable interest and hence, there is a large number of relevant published works (Hollingswoth, Dawson and Maniadakis, 1999).

As far as it concerns the objectives of the published studies, they mainly aim at the evaluation of market structure and performance, average and best practice technologies, competitive pressure and performance, optimum firm size and assessment of system reforms.

The output of the hospitals industry is multiple and heterogeneous, and hence it is difficult to capture in discrete countable units. Consequently, proxy measures of hospital output must be employed. In the literature of hospital efficiency and productivity measurement, the following outputs are often used as proxies of the hospital output: number of patients, patient discharges, cases treated inpatient days, outpatient cases and day cases. They are often adjusted for the status of patients their age and sex. Moreover, it is common to standardise output either using the service-mix or the case-mix approach.

The first stratifies patients either according to the facilities of the hospital or by the medical services administered during treatment, whereas the second involves clustering patients into Diagnosis Related Groups, case severity or specialty mix (Tatchell, 1983). Contrary to outputs, the specification of inputs is more straightforward and includes: doctors, nurses, technical, administrative and other categories of staff, staff hours or salaries or ratios of staff to patients, beds, value of assets, and running costs disaggregated in various categories.

Finally, to investigate the determinants of better performance, efficiency scores are in some cases regressed against various explanatory variables such as ownership, occupancy rate, age of the institution, method of funding, number of staff and staff costs, case-mix and age-mix and location of the unit.

In the present analysis it is assumed that hospitals organise and expend the production and delivery of health care and health, labour resources such as doctors, nurses and other personnel and capital resources which are reflected by beds and operational expenses. Inputs are used to produce *intermediate outputs*, which are the services produced, such as outpatient and inpatient care, laboratory examinations and surgical interventions. The hospitals in the sample are homogeneous as they are all acute care units and are located in the same region.

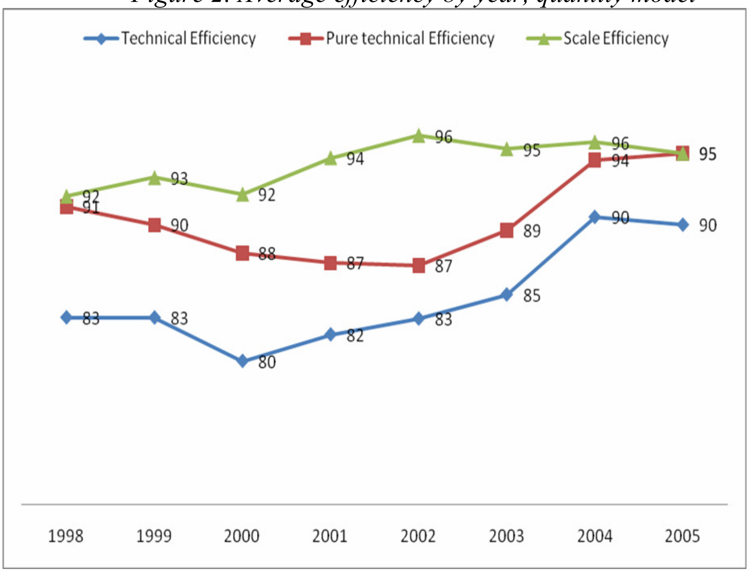
The data were obtained from the Second Regional Health Authority of Attica and involve the years 1998 to 2005. All years are used to estimate one frontier, which in this case represents the best observed performance in the period under evaluation and hospitals in each year are evaluated against the super-cross-time frontier, which represents the observed ideal across any time and it can be constructed by hospital data corresponding to different time periods.

Economic data were deflated using the Health Care Services deflation index obtained from the National Statistical Service.

5. Results

Table 1 presents information on the input and output data of each individual hospital. Figure 2 depicts average efficiency scores across time when only inputs (doctors, nurses, other personnel, hospital beds) and outputs (laboratory examinations, surgical interventions, outpatient and inpatient cases) are considered.

Figure 2. Average efficiency by year, quantity model

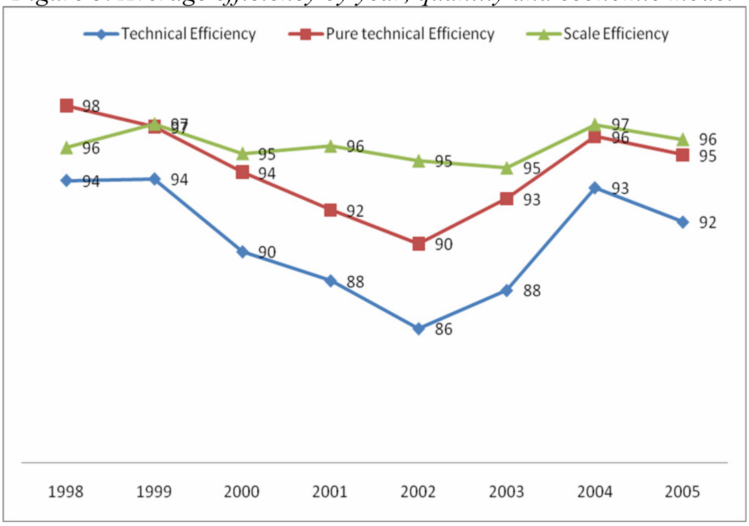


It is seen that overall across the sample studied technical efficiency decreased from 1998 to 2000 and then increased steadily subsequently. Overall technical efficiency increased from 83% in 1998 to 90% in 2005. This means that hospitals were able to produce the same amount of output using 7% less inputs. It is also seen that the turning point was that of the time around the reforms. In terms of the underlying trends, scale efficiency increased from 92% in 1998 to 96% in 2002 and then it stayed fairly constant. In any case, the hospitals under evaluation are quite efficient in terms of their scale of operations. The trends in technical efficiency were determined by the pure technical efficiency of hospitals. In this respect, it is seen that pure technical efficiency fell from 83% in 1998 to 80% in

2000 and then it rose to 90% in 2005. Thus, not so much the scale of production but the ability of hospitals to transform inputs into intermediate outputs defined their performance trends. It is also seen that the reforms and the efforts may have after all achieved their objective to increase hospital pure and scale technical efficiency.

Figure 3 depicts the situation where the operational expenses (other than wages and capital investment) of hospitals are taken into account in the analysis and they are considered as an additional input in the model.

Figure 3. Average efficiency by year, quantity and economic model



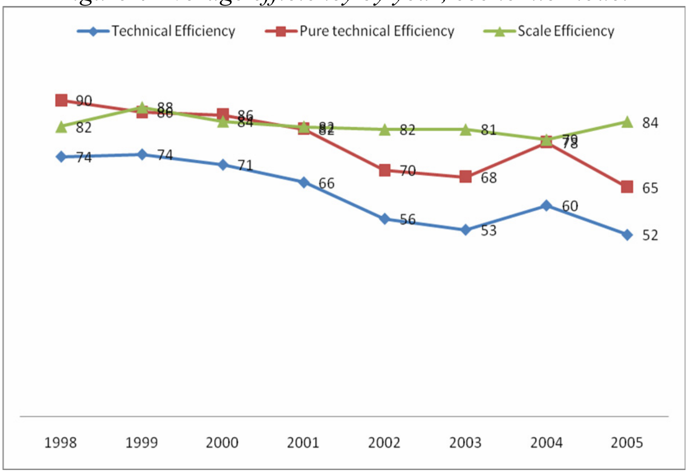
It is seen again that scale efficiency was fairly constant, around 96%, across the sample and the period of analysis and it was pure technical efficiency that led the trends in performance. In particular, pure technical and overall technical efficiency decreased from 1998 to 2002 and increased subsequently, even though it is noted a regress in 2005.

Thus, pure technical efficiency dropped from 98% in 1998 to 90% in 2002 and then rose to 95% in 2005, a net decrease of 3%. Similarly, overall technical efficiency dropped from 94% in 1998 to 86% in 2002 and rose to 92% in 2005, a net decrease of 2%. These data imply that the cost of health care delivery increased dramatically in the period 1998 to 2002, without a corresponding increase in the delivery of services. After 2002 there was an increase in the delivery of services, nonetheless there was not enough to offset yet the loss of the first part. It is notable also that in 2005 there a regress.

To analyse the impact of operational costs on productive performance an analysis was performed were outputs stayed the same but the only input considered was operating expenses. It is seen in figure 4 that during the entire period of analysis efficiency is reducing, in other words, hospitals are spending more to produce the same amount of output.

Thus, it is obvious that hospitals became better in managing their resources apart from operating expenses. In fact, as seen in figure 4, the drop in operating expenditure efficiency is dramatic in the period of analysis as it falls from 74% in 1998 to 52%.

Figure 4 Average efficiency by year, economic model



The above analysis and figures imply that, taking into account best observed performances, when resources only are considered in 1998 hospitals on average could produce the same output using 17% less quantities and in 2005 that figure decreased to 10%. This is a significant progress and the slack in the sample has reduced, implying better use of human and capital resources.

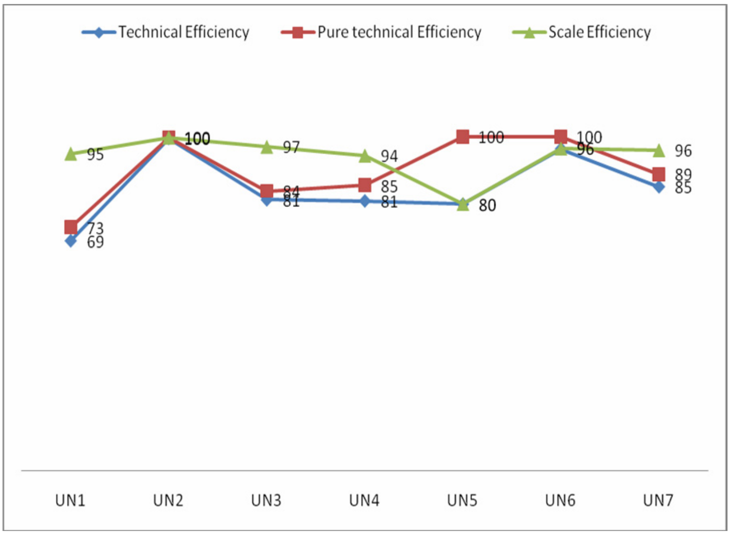
However, this picture reverses when operating expenses are taken into account. It is seen that in 1998 hospitals could run with 26% less operating expense and this rose to 48% in 2005. Thus, overall when labour and capital input as well as operating expenses are considered, in 1998 hospitals could produce the same output with 6% resources and expenses, which then rose to 8% in 2005.

Thus, despite an improvement is that the last few years, hospitals overall have deteriorated in terms of their efficiency. Operating expense inefficiency may be due to the fact that hospitals are using excess amount of consumables or the wrong mix in light of their prices.

It may also be explained in light of extra expenses in preparation for the Athens 2004 Olympic Games, which did not demand or result in production of higher volume of services.

In terms of individual hospital performance, Figure 5 depicts the efficiency of hospitals across years in the model with input quantities only.

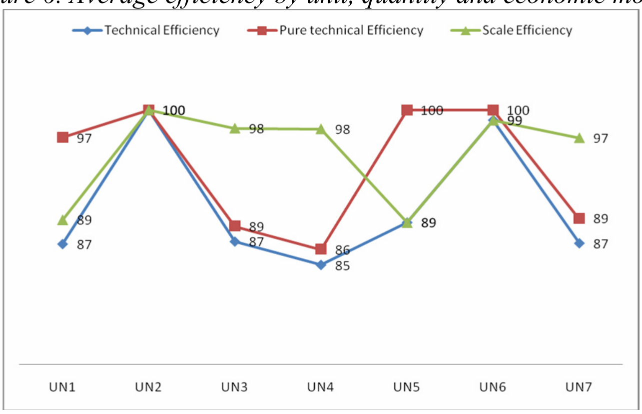
Figure 5. Average efficiency by unit, quantity model



It is seen that hospitals 2 and 6 are the best performers in the sample. Hospitals 1, 3, 4 and 7 are inefficient because of pure technical inefficiency, whilst hospital 5 is pure technically efficient but operates at wrong scale of production.

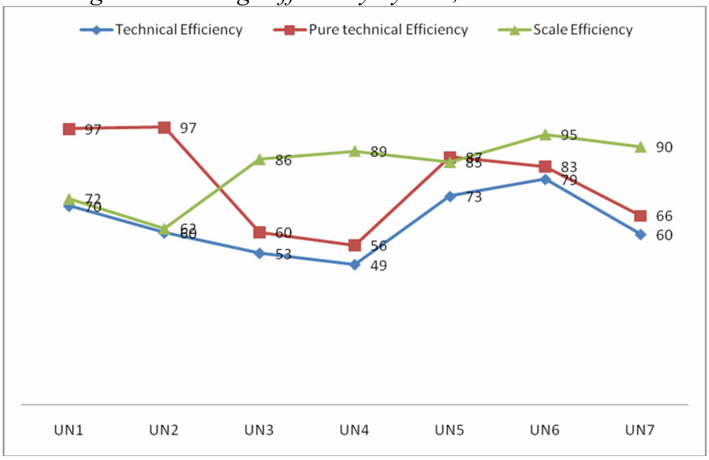
The situation is similar in Figure 6 where operating expenses are also taken into account alongside quantity inputs.

Figure 6. Average efficiency by unit, quantity and economic model



Finally, in Figure 7 it is seen that all hospitals have low efficiency when only operating expenses are taken into consideration in the analysis.

Figure 7. Average efficiency by unit, economic model



The above average hospital performance measurements are the aggregates of varying trends at the individual hospital level. This is seen in Figure 8 and 9 which display overall technical efficiency scores per unit and year based on the model which includes in the input quantity and economic variables.

Figure 8. Individual hospital efficiency by year, quantity and economic model

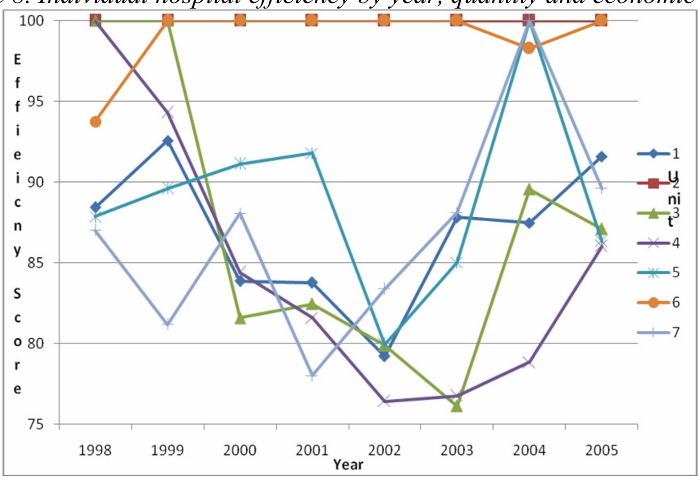
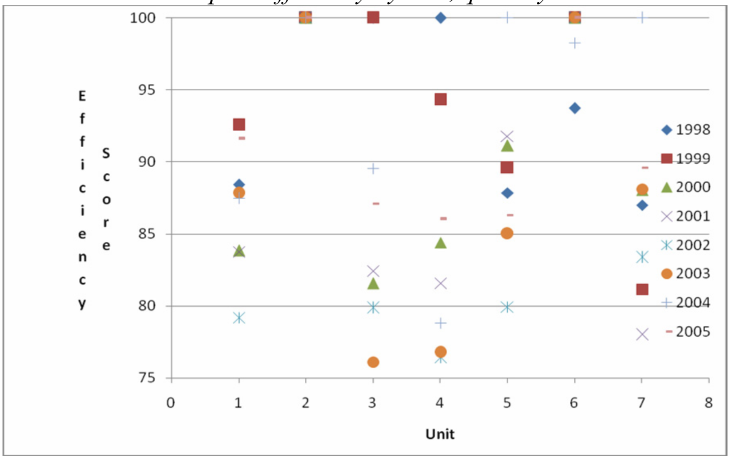


Figure 9. Individual hospital efficiency by unit, quantity and economic model



6. Conclusions

Over the last decades the measurement of efficiency and productivity in the health care sector has attracted significant interest. Health care markets encompass all the characteristics of an imperfect market. Market failures have resulted in inefficiencies and have contributed to the escalation of health care costs.

In the search of the factors, which determine the growing trend of health care expenditure and inefficiency, the list would include the ageing of population, over insurance, cost increasing technology, increased patient expectations, low growth productivity, supplier induced demand, agency relationship and the relative price effect. Recently, it has been argued that inefficiency, due to excessive input utilisation and incorrect input proportions contributes to the escalation of health care costs. Hospitals are the major consumers of health expenditure and do not adhere to traditional optimising economic behaviour. Hence, the quantification of hospital efficiency and productivity has become a major concern for both health policy makers and health managers.

In this paper a mathematical programming method to efficiency measurement was employed to assess whether the health care reforms of the early 2000s' achieved their objective to increase hospital efficiency in Greece. We employed a model were outputs considered include interventions, laboratory examinations, outpatient and inpatient cases. Inputs considered include beds (capita input factor proxy), doctors, nurses and rest personnel (labour input factor) and operational expenses (short term input factor).

The analysis indicated that in general there was efficiency regress in the period from 1998 to 2002 and progress thereafter up to 2005. The progress is substantial when only input and output quantities are concerned. Hospitals overtime became more efficient in managing their resources. Nonetheless, the situation is different if only the economic variable is considered as an input. In this case there is a significant regress in efficient implying that hospitals are using more money to produce same amount of output. Thus, the decrease in operational economic efficiency offsets the increase in the efficiency of managing the labour and capital resources and overall there is a small decline despite the progress of the later years.

These results imply that there are opportunities at the individual hospital level, but on average the hospitals under investigation cannot improve anymore their efficiency significantly by changing their scale of production and their efficiency in running their labour and bed inputs. Instead management should focus on handling better their operating expenses which as the analysis indicates can be halved, on the basis of the performance of best practice units.

The present study has obviously caveats. It is not adjusting for case mix and service quality. Obviously this is a homogeneous hospital sample serving the same population, but taking into account in the analysis the factors mentioned above will improve it further. Also, the sample is small and it considered only hospitals in a single region and thus the frontier is a local one.

Enhancing the sample size will improve the analysis and it will make it possible to compute Malmquist indexes or other measures of total factor productivity to analyse the impact of technical change, in other words the shifts of the frontier itself. Finally, it will worth it to associate performance with hospital and management characteristics in an effort to find out what determines best productive performance and to guide decision making and management.

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