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Efficiency Study of Greek Health Units of the Public Sector using Data Envelopment Analysis Method, before and during the start of the Economic Crisis

Georgios I. Farantos[1] and Nikitas Spiros Koutsoukis[2]
[1] *Department of Political Science and International Relations, University of Peloponnese, 1 Aristotelous Str. & Athinon Ave., Korinthos, Greece, gfarantos@uop.gr, grfrinark@gmail.com*
[2] *Department of Political Science and International Relations, University of Peloponnese, 1 Aristotelous Str. & Athinon Ave., Korinthos, Greece, nkoutsou@uop.gr*

Abstract

Purpose *– The purpose of this paper is to investigate the Technical Efficiency through an Efficiency Study of Health Units of the Greek Ministry of Health, before and during the start of the Economic Crisis in Greece.*
Design/methodology/approach *– The research has been designed to collect data regarding the Health Units of the Public Sector from the Greek Statistical Authority (ELSTAT) and to process that data with the use of the Data Envelopment Analysis software. The methodology of the research extends to the application of the Efficiency Study of Decision Making Units (DMUs), the study of variations of Technical Efficiency during a number of years and the extraction of conclusions regarding variations in Technical Efficiency at a time period before and during the start of the Crisis. Data from large Health Units was used in order to achieve comparison of the results.*
Findings *– We calculate the DEA scores based on the most common DEA models (CCR, BCC and Super Efficiency) for the Health Units of the Greek Ministry of Health. We examine the variation in Technical Efficiency of the Health Units during the extent of the time period of the study. The Efficiency Study of the Health Units leads to useful conclusions regarding the variation in the observed Efficiency of the Units and the integration of the Efficiency variation studies, as part of the initial stage of an Integrated Crisis Management. The research ranks the efficient and non-efficient units and suggests ways of improvement.*
Research limitations/implications *– This is a study about the Health Units of the Public Sector using size as a criterion. The investigation is limited to the Public Health Sector and its conclusions cannot be extended to the Private Health Sector. There are no geographical restrictions.*
Originality/value *– This is an innovative research which allows for further case studies in the future and completion of Efficiency studies after the end of the Economic Crisis.*

Keywords: Economic Crisis, Data Envelopment Analysis, Efficiency Study, Decision Making Unit, Health Units.

JEL Classification: C60, I1, H12.

1. Introduction

The aim of this paper is to investigate the Relative Efficiency of Healthcare Units of the Greek Ministry of Health (Public Sector), through a comparative Efficiency Study for a period preceding the onset of the Economic Crisis and ending at the beginning of the Economic Crisis. Subsequently, the Efficiency performances form part of a new application for changing Relative Efficiency and the knowledge acquired can be used in Doctoral Studies. The research methodology extends to the implementation of an organisation's Efficiency Study using factual health units' data provided by the Greek Statistical Authority (ELSTAT) and integration of the analysis in part of the interpretation of the Economic Crisis framework.

For the measurement of the Technical Efficiency of health Decision Making Units (DMU), Data Envelopment Analysis (DEA) was used. The DEA is a non-parametric method for the measurement of Efficiency of a Decision-Making Unit (or Unit), such as an organisation or the Public Service (Ray, 2004) and is a mathematical method of linear programming measuring Efficiency systems (Ozcan-Gunai & Tektas, 2006). The DEA compares the total inflows and outflows of several DMUs based on the principle that the DMUs transform inflows into outflows (Thanassoulis, 2001). The DEA neither discovers nor uses production function which links inflows to outflows, but uses only the inflows and outflows themselves, solving a system of equations in order to calculate the values of the inflows or outflows so that the DMU becomes a profitable one.

Farell, based on the work of Debrew (Debrew, 1951), who analysed the Efficiency of financial systems (according to Pareto) and Koopmans (1957), developed DEA's basic concepts (Coelli, 1996). Farell expressed the overall Efficiency of the production DMUs with the total productivity factor. Farell defined Technical

Efficiency as the combination of production factors defined by the production function and used for the production of the maximum amount of outflow without wasting them and Economic Efficiency or Allocative Efficiency which refers to the combination of inflows which minimises production costs, given the values of those figures (Farell, 1957).

Charnes, Cooper and Rhodes (1978), defined the Decision Making Units and introduced the DEA method as a method of linear programming for the measurement of systems' Efficiency, implementing it particularly to bodies of non-profit public programmes (Charnes, Cooper & Rhodes, 1978). The DEA model they developed and which was named CCR is the basic DEA model referring to steady return to scale (SRTS), namely that changes in outflows are proportional to changes in inflows. The CCR model creates the Production Probability Set (PPS) (Thannasoulis, 2001) and the effective threshold, which consists of few DMUs exhibiting exactly the same maximum Efficiency, thus characterising a very large percentage of DMUs as inefficient.

Banker, Charnes and Cooper (1984), then developed a model which was names the BCC model and refers to the variable Efficiency scale - Variable Return to Scale, that is, when the change of inflow leads to a non-proportional change in outflow. The BCC model achieved a widening of the effective limit with the introduction of DMUs characterised by the CCR model as inefficient and thereby characterising the units based on Relative Efficiency with respect to a minimum acceptable Efficiency threshold rather than their absolute Efficiency (Banker, Charnes & Cooper, 1984). The BCC model is now used by most researchers for the decision-making DMUs or in comparison to the CCR model.

Then, younger scholars developed new mathematical models of the DEA method in order to extend the method, such as the Andersen and Peterson models, which defined the Efficiency Index as greater than the unit and explained the circumstances under which the ultra-productive models are unreachable; Doyl and Green, who calculated the Efficiency of DMUs multiple times and showed the results in Efficiency cross tables. Also, the Cook *et al.* model, with the DEA extension for the handling criteria of a qualitative nature, the Torgesen *et al.* model, with the efficient DMUs classification methods based on savings or production gain, the Friedman *et al*. model with the overall framework which includes normal relevancy analysis and a multiple delivery method and the Sowlati *et al*. model with a group of technical projects and the comparison of inflow and outflow criteria of real projects (Sowlati, 2005).

The basic mathematical models of the DEA method with the stated limitations are shown in Table 1 (based on Charnes, Cooper & Rhodes (1978); Banker, Charnes & Cooper, (1984); Farantos (2015)). The mathematical relationships along with the limitations that have been used in the basic mathematical models are explained.

According to Arkay, Ertek & Buyukoskan (2012), the DEA has a leading role amongst non-parametric Efficiency measurement methods, analysing its many advantages (such as performance measurement opportunities and benchmarking, requirement of small computing power, ideal for handling large numbers of DMUs) in comparison to its few disadvantages (such as intense influence from possible errors and extreme data points) (Arkay, Ertek & Buyukoskan, 2012).

The DEA is classified among the non-parametric methods of Linear Programming for the measurement of Efficiency of businesses and bodies and prevails among the other non-parametric methods (Free Disponsable Hull, Analysis Indicators) as well as among Parametric Methods, such Stohastic Frontier Approach (SFA), Distribution Free Approach (DFA), Thick Frontier Analysis (TFA), Ordinary Least Squares (OLS) and Financial Methods Regression (Bauer *et. al.*, 1998).

The Pareto Efficiency (Pareto Optimum or Efficiency) is defined in the DEA using diversification of the control exercised by the DMU towards the inflows or outflows, based on whether the DMU can increase its outflow without further increase of inflow in the case of control of inflow, or if the DMU can reduce inflows without further reducing outflow in the case of control of outflow (orientation of outflows). The DEA borrowed and used the concept of Pareto Efficiency from Economics Science (Thanassoulis, 2001).

During the application of the DEA method some inputs and outflows are exhibited, the control of which is not under the DMU control. These inflows and outflows are called non-discretitive or exogenously defined. The exogenously defined inflows and outflows are important for the implementation of the method, are treated in a special way and modern models have been developed to achieve their handling and integration into a comprehensive application of the method (Banker & Morey, 1986).

The Efficiency of the DMUs can only be accessed through a rigorous mathematical solution of the DEA method. Existing opinions or information which are generally accepted or incorporated into written text or previous assessments can be used to be introduced in the DEA models in order to ensure extraction of more reliable conclusions (Allen *et al*., 1997).

The DEA method often uses sensitivity analysis. The sensitivity analysis is the process of handling faulty or incomplete data. The sensitivity analysis is performed by the operation of several models for the same DMUs, in which some inflows or outflows are replaced by other inflows or outflows, in order for the results of the original model to be confirmed or ruled out and to compare the results of the models. Then a single set, containing the comments for all models used in the sensitivity analysis, is generated.

Strategic Management and the DEA are connected to modern organisations. Strategic Management includes the vision, mission, objectives and goals, of which the degree of their achievement is confirmed or refuted by the application of the method (Allen *et al*., 1997).

A model for the application of the DEA model in the ranking of Information Systems projects with financial institutions was developed by Sowlati, Paradi & Suld. The researchers examined the Information Systems so

as to find the most effective one in order to reach decisions which are more beneficial to the operation of the organisations. Researchers believe that political interference is a hindrance to improving the Efficiency of organisations and propose the implementation of financial criteria in view of this improvement. (Sowlati, Paradi & Suld, 2005).

The utilisation of the applications, the policies and health strategies for health institutions was analysed by Renner et al., who proposed the creation of an Efficiency measurement and strategy implementation system in the Health Regions of the Sierra Leone. In their study the effect of non-Efficiency of Health Units on the realisation of local and international health goals is observed. (Renner *et al.*, 2005).

Economou et al. (2015) measured the efficiency of the Greek rural primary health care, using a restricted DEA model in southern and western Greece. The results demonstrated noteworthy variation in efficiency. The results indicated potential for considerable efficiency improvement in most rural health care units, with emphasis on prevention and chronic disease management, as well as wider structural and organisational reforms.

The Efficiency studies, as decision-making tools, are used for the creation of proposals for the realisation of objectives, for future policy planning and improvement of the utilisation of future resources. (Movahedi et al., 2007).

Table 1: Basic Mathematical DEA Models

General DEA Model (Charnes, 1978)	Mathematical formulation DEA Model	CCR Model Charnes & Cooper & Rhodes (1984)	BCC Model
Efficiency= $\frac{\sum_{r=1}^{s} UrYrj}{\sum_{i=1}^{m} NiXij}$ *i* is the footnote of entries (*i* = 1,2,…..m) *j* is the annotation of DMUs (*j* = 1,2,…..n) *r* is the annotation of exits (*r* = 1,2,….s) *Xij* is the i entry of j DMU *Yrj* is the r exit of j DMU s is the number of exits m is the number of entries n is the number of DMUs	S Σ UrYro r=1 Efficiency DMUo= m Σ NiXio r=1 subject to (Restriction) $\frac{\sum_{r=1}^{s} UrYrj}{\sum_{r=1}^{m} NiXij} \leq 1$ Ur>=0 Ni>=0 *i* is the footnote of entries (*i* = 1,2,…..m) *j* is the annotation of DMUs (*j* = 1,2,…..n) *r* is the annotation of exits (*r* = 1,2,….s) o is the DMU under examination *Xij* is the i entry of j DMU *Yrj* is the r exit of j DMU s is the number of exits m is the number of entries n is the number of DMUs	$Maxho = \sum_{r=1}^{s} UrYro$ s.t. (Restrictions) $-\sum_{r=1}^{s} UrYrj + \sum_{i=1}^{m} NiXij \geq 0$ $\sum_{i=1}^{m} NiXio = 1$ Ni>ε Ur>ε or $Minho = \sum_{i=1}^{m} NiXio$ s.t. (Restrictions) $-\sum_{r=1}^{s} UrYrj + \sum_{i=1}^{m} NiXij \geq 0$ $\sum_{r=1}^{s} UrYro = 1$ Ni>ε Ur>ε	Additional Restriction $\sum_{j=1}^{n} lj = 1$ {(X,Y):>=ΣxjΛj και Y<=ΣyjΛj}

Source based on Charnes, Cooper & Rhodes, 1984 and Banker, 1980.

2. Efficiency Study and Crisis Management

The study aims to integrate the study on efficiency with the DEA method in a pre-crisis period, in a comprehensive crisis resolution framework. In the past, an efficiency study using the DEA method was performed on the Turkish banks, demonstrating how the advent of the Economic Crisis affects Efficiency (Ozcan-Gunai & Tektas, 2006).

The effect of the Iranian Crisis on the Efficiency of railways was analysed by Movahedi et al. This Crisis was caused by the Islamic Revolution and the subsequent war. The study analysed the period 1971-1985 and showed a negative change of efficiency measures due to the impact of the Crisis. (Movahedi et al., 2007).

The DEA method has been used in Argentina to study relative efficiency for several years (2003-2007), during a period when the traffic of units (airports) had decreased by approximately 50%. DEA was used in two stages in order to draw conclusions about the impact of the economic crisis o the change of the DMUs efficiency (Barros, 2008).

After the Asian economic crisis of 1997, the banking system of the Philippines entered a series of

malfunctions. The DEA method, using the Malmquist index for the comparison of efficiency at different time periods, was used to measure the change in relative Technical Efficiency of banks under the influence of the Economic Crisis over an extended period (Dacanay, 2007).

During the period prior to the Greek Economic Crisis, the Hellenic Health System faced serious problems, such as operational deficiencies, inadequate management, funding problems and lack of evaluation mechanisms. These problems accumulated despite the multiple and diverse legislative initiatives which took place over a period of 30 years before the Economic Crisis. These problems made the country's health system particularly vulnerable to fluctuations in the economy. The lack of specific provisions for the forthcoming advent of the economic crisis in the health field and lack of institutional and functional shielding of the Hellenic Health System led to loss of preparation and weakness in handling the new data (Economou, 2010).

Crises generally occur frequently in modern societies. Crises affect all management levels of an organisation. The levels of an organization which are under threat because of the crisis are the mental, physical, moral and spiritual ones (Mitroff, 2005). Threat, uncertainty and the sense of urgency are characteristic features of each crisis (Boin et al, 2005).

Economic Crises occur when a period of steady growth development is followed by a period of decline. The current global Economic Crisis, which affects and interacts with the national crises, is due to a Crisis of the social and political state. Modern societies developed their social and political state in its present form after the Second World War, in order to address social problems and to avoid a Crisis similar to that of the 1930s. However, the modern social and political state did not work in the desired way and in the process exhibited failures and malfunctions that led to the modern Economic Crisis (Castels et al., 2012).

The Economic Crisis in Greece, is closely linked to the global Economic Crisis. The Greek Economic Crisis started in the early 2010. Greece's developmental and financial debt reached great heights and Greece's economic weakness indexes exceeded those of all other countries of the Euro zone. An explanation for the Greek financial crisis is considered to be the corruption of politicians and the ruling class and the government's appeasements after the political changeover following the junta (Matsas M., 2010). Greece's continuous course in the direction of European integration and globalization played an important role in the development of the Economic Crisis in Greece (Lesser, 2005).

Economou et al. (2014) analysed the effects of the Economic Crisis on Health and the Health System in Greece. They analysed the responses of the health system during the crisis, the changes in the public financing of the health system, the coverage of insured persons, the changes in the design of health services as a result of a reform effort that Greek governments have attempted mainly to target the reduction of costs and the increase the efficiency of health services.

Economic Crises occur periodically depending on a growth rate of the economy based on the recurrence of the economic situation (during the economic situation's main path). The intensity and the recession of the economy alternate between periods of flourishing and periods of crisis. Russian economist Nikolai Kondratiev studied the recurrence of economic activity and summed up the results of this study in the theory of economic cycles (Kondratiev cycles or Kondratiev Waves). According to this theory, new technology causes economic flourishing and a sense of euphoria that favours the economy. But as the evolution of this technology completes its cycle and the technology is incorporated in everyday life then the Crisis appears. Schumpeter and other followers of the theory of economic cycles completed the theory by stating that these cycles appear every 50 years and result in a major crisis or a world war. In between these long-term economic cycles, medium or short-term cycles manifest. (Korotayev, Zinkina & Bogevolnov, 2011). The K waves were identified a hundred years ago, but there is no comprehensive theory of interpretation, although their existence has been proved experimentally. (Grinin, Devezas & Korotayev, 2012). The modern global Economic Crisis and hence all Economic Crises associated with it, are included in the economic cycle of Information Technology, which after developing for half a century is nearing its recession creating a "Kondratiev winter".

Crises go through a cycle consisting of stages which refer to conditions prior to, during and after the crisis (Mitroff, 1996), (Fink, 2002). Crisis Management has been found to follow the three stages of a Crisis which are the stage preparing for the Crisis and integration of experience from previous Crises, mainly Crisis Management with the use of Crisis Management Support Systems (CMSS) and post-Crisis recovery and damage restoration. (Combs, 2007; Augustine, 1995; Olson, 2009). An Integrated Crisis Management (ICM) may include the Crisis Management corresponding to the three stages, that is, Risk Management, Crisis Management and Disaster Management. The Integrated Crisis Management is differentiated into sequences depending on the type of the present crisis and the course used to approach it (Farantos & Koutsoukis, 2015).

In this study a comparative Efficiency Study of a period of 5 years prior to and during the start of the Greek Economic Crisis is carried out. We use a model for the comparison of the Efficiency scores derived from the processing of the results. We try to identify major changes in the Efficiency scores in order to identify impacts of Administrative Reforms aiming to alleviate the bureaucracy which we identified as taking place during the period under consideration. We use the results in order to enrich the Integrated Crisis Management with knowledge about the behaviour of organizations with respect to the effective measures before the start of the Economic Crisis and we draw conclusions about the contribution of the implemented reforms.

During the period under study (2006-2010), the Greek Government tried to implement major reforms aimed at increasing the Efficiency of Health Units mainly through bureaucratic relief. These reforms constitute a continuation of the constant reform efforts in the field of Health which have been implemented since the political changeover following the junta (1974). The reforms of the study period focused on the reduction of operating costs of Health Units, mainly through the reduction of procurement costs, the application of new information technologies and the use of Information Systems. In this way, the reduction of inflows was intended which would consequently increase Efficiency. The reform provisions for the operation of Health Units during the period under consideration are shown in Table 2 (based on Papageorgiou et al., 2014. The description and evaluation of each reform effort are given.

The provisions of the Ministry of Health established the details of the implementation of the procurement system, simplification of bureaucratic procedures and reforms affecting the Efficiency of Health Units especially in the application of Information and Information Systems. It was considered that the introduction of the procurement system and electronic tendering and procurement services in accordance with international practices would contribute to the increase of Efficiency by reducing costs. Electronic registers of products and services as well as electronic registers of suppliers and providers were also considered to reduce inflows and economise on resources ultimately increasing the Efficiency of health units. The clinical and administrative systems implemented in hospitals during the study period (which were later used as legacy systems to other systems that were designed to increase Efficiency during the Economic Crisis) have attempted to benefit the efficient functioning of the administration through the optimization of the quality of the Services, organization of large amounts of information, reduction of bureaucracy, rationalization of cost management, improvement of resource use, and from the perspective of human-factor, better patient care, reduced waiting times, reduced human errors, better patient service and reduced hospitalization. The DEA method is used in this study in order to assess the fluctuation in the efficiency scores of Health Units during the whole period under study. In this way, the impact of the reforms undertaken in the Health Units on the efficient operation of the plants can be assessed. To assess the effect of the administrative reforms that took place during the study period regarding the efficiency of the DMUs the application of Data Envelopment Contrast Analysis (DECA) is used (Farantos, 2015b).

Table 2: Reform provisions for the operation of Health Services in conditions of pre- Economic Crisis

Provision Name	Year	Description	Evaluation
L. 2716/99	1999	Law on Mental Health - Application of programme "Psychargos" - De-institutionalisation of patients	Closure of majority of psychiatric hospitals, development of day units and hostels in half receivables, non-application of Efficiency measurement
P.D. 60/07	2007	Contract Procedures for Procurements - tendering. Introduction of agreement procedures by a Health Region.	Positive evaluation regarding its implementation.
L. 3458/07	2007	Publication of contract notices for supplies or services to the daily press.	Positive evaluation regarding its implementation.
L.3580/07	2007	Supplies of Ministry of Health bodies. Establishment of Committee of Health Supplies (C.H.S.) aimed at the designing of a supply system for Hospitals. Establishment of Registries of Certified Products and Services and Certified Suppliers & Service Providers. Establishment of a system of quality control of supplies and services carried out by limited companies.	Difficulties in the implementation of the supply system.
P.D. 118/07	2007	Analysis of processes and regulations governing competitions and public procurements with extensive reference to the required technical specifications	Benefit from the concrete specifications but bureaucratic delay.
L.3846/10	2010	Establishment of price monitoring and possibility of e-procurement for supplies and services.	Objectivity in execution of competitions.

L.3867/10	2010	Establishment of possibility of tendering without authorisation from the appropriate Health Region up to the amount of €45000. Obligation for marking of lower price for supplies and services regarding medical devices.	Simplification of bureaucratic procedures.
L.3868/10	2010	Improvement of the organisational structure of the Ministry of Health bodies. Configuration of the day operation of hospitals, incentives for the coverage of needs of the region, configuration of administrative issues of Health Regions and Hospitals, Establishment of Consultation, Transparency & Accountability Councils and Regional Health Planning & Social Care Councils in Municipalities and Regions. Establishment of 28 powers of the National Council for Public Health (N.C.P.H.).	Reforms which affect the Efficiency of the management of health units.

Source based on Papageorgiou *et al.,* 2014
Note: L.: Law P.D.: Presidential Decree.

DECA is based on the comparison of the efficiencies of the DMUs in two or more time periods, related to the study of a phenomenon such as the economic crisis or the pre-crisis period. If we already know some DMUs' inflows and outflows, we use the DEA method to extract the DMUs' efficiency score. The implemented reforms cause changes in the operation of the DMUs in order to make them more efficient by reducing inflows.

We study the variation of Efficiency scores during the study period, by dividing the DMUs into three categories; efficient ones, i.e. those which have been within the efficiency level for at least one year of the studied period, the top 10 non-efficient ones, i.e. those not included in the efficiency level but are the top ones just below the efficiency level limit and whose efficiency is, theoretically, easier to improve, and the 10 least efficient ones, i.e. those that are far from the efficiency level and have great room for improvement. In this way, we interpret the change in Efficiency scores as to the Efficiency level. Through analysis the results of the study, we draw useful conclusions about the effect of the implemented reforms on the change of the Efficiency of the DMUs during the studied period.

3. Case study of Health Units with the DEA method

The Case Study of Health Units with data provided by the Greek Statistical Authority (ELSTAT) begins with the selection of DMUs to be used. The selection of DMUs is the first step towards the implementation of a DEA study (Banxia, 2001). We select 105 DMUs using size as a criterion. These units are located in major cities of the country and also scattered in all regions of the country, without any geographical restriction. We use code numbers for the units based on the figures provided by ELSTAT (Hellenic Statistical Authority) and not serial numbers, in order to allow for further expansion of the research by comparing the performance of the DMUs one by one.

We measure the Technical Efficiency of large health units (Health Care Hospitals) of the Greek Republic. During the selection process the geographical distribution of the Health Units is not taken into account. According to Mariolis et al. (2008), Greek citizens express significant dissatisfaction with the provided Health Care services (Mariolis et al, 2008), therefore the application of the DEA method is important because the DEA Efficiency Studies offer important tools for the improvement of the DMUs' Efficiency. In order to receive the data an agreement between the researchers and the Greek Statistical Authority is signed and permission to process such data is received by the Administration of the Greek Statistical Authority (ELSTAT.). The Health Units are not shown by name but by code numbers. We choose to use the data relating to the largest Health Units since the DMUs must use the same inflows and produce the same outflows but also fully developed DMUs should not be compared to very small DMUs that could create a false picture of the score Efficiency. The selection of data inflows and outflows is the first and perhaps most difficult point in the assessment of Efficiency (Scheel, 2000). Table 3 shows the numbers and names of the inflows and outflows that we choose in order to supply data to the DEA model X. It also shows the status of each inflow and outflow as exogenously defined.

We used the free software EMS130, developed by Holger Scheel, which enables the processing of exogenous defined inflows and outflows. The results of the software are verified by other free software.

For Model X of our analysis, we use two basic mathematical DEA models, the CCR model, which ranks the DMUs by selecting the ones with ultimate

Efficiency as efficient, judging a small number of DMUs as efficient and the BCC model, which categorises more DMUs as efficient compared to the previous model, expanding the effective threshold to a larger number of efficient DMUs.

Most importantly, we use the Super Efficiency model, which categorises the DMUs in descending order and in this way apart from creating an effective limit for DMUs with a rating above 100%, it is mainly useful for the comparison and improvement of inefficient DMUs and for the creation of proposals for their improvement and their classification as efficient (Yawe, 2010).

Table 3: Definition of inflows – outflows of study on Efficiency of Health Units

Model	Inflows			Outflows		
Name of Model	Number of inflow	Name of inflow	Hexogenous determination	Number of outflow	Name of outflow	Hexogenous determination
Model X	I1	Number of Doctors	No	O1	Number of outgoing patients	Yes
	I2	Number of Nurses	No	O2	Number of days of hospitalization	No
	I3	Number of administrative staff	No			

We choose to use the BCC model which is referred to in the variable return to scale (VTRS), in order to assess a broader Efficiency limit consisting of several DMUs, against the CCR model. Nevertheless, we use the CCR model as a supplement, in order to proceed with the comparison with the BCC model. We prefer the BCC model BCC to the CCR because in our case the increase of inflow does not cause a corresponding increase in outflow, to expand the Efficiency threshold and because in the case of health facilities, the demand for health services is not dependent on administration (Yawe, 2010). The results are freely optimised due to the number of DMUs and the dissemination of results. We create a table of processed data to proceed to the analysis of results.

From Table 4, we see the following values for the number of efficient DMUs: 13 efficient DMUs for 2006 (a percentage of 12.38%), 10 for the year 2007 (9.52%) 7 for the year 2008 (6 .66%), 10 for 2009 (9.52%), 11 for 2010 (10.47%). It is reminded that the DMU codes are those originally used by ELSTAT. The percentages in the year columns are the DMU efficiency scores for each year with big being the highest value. Values over 100% are due to the use of the Super Efficiency model which is used for ranking the units in absolute values. The units that exceed 100% are placed above the efficient level (while in another model on the effective threshold).

It is observed that there is no specific upward or downward trend for the values of efficient DMUs during the period under consideration. With the exception of year 2008, the number of efficient DMUs is around 10% of the total. We can conclude that the implemented reforms during the period 2006-2010 did not lead to the desired increase in the Efficiency of the DMUs, but to a slight reduction if we focus on the years 2006 and 2008. We also notice that the DMUs that maintain the first position, DMUs 10, 197, 232 occupy the first place for several years, which shows a stability in the occupation of the first place, without being affected by the Administrative Reform. Many other DMUs which were characterised as efficient, exhibit a random fluctuation in their Efficiency scores sometimes being placed above or below the Efficiency limit during the years, a fact which also does not confirm the impact of the reforms on the increase of Efficiency of the health units.

Table 4: S.E. Table of relevant Efficiency of efficient Health units - period 2006-10

DMU	2006	2007	2008	2009	2010
10	66,55%	big	Big	big	big
13	57,52%	100,13%	58,59%	62,14%	53,34%
15	73,66%	140,40%	57,00%	57,78%	65,02%
18	48,72%	57,66%	54,72%	108,45%	136,97%
28	67,54%	95,76%	217,69%	198,69%	186,42%
29	63,72%	104,37%	61,69%	55,99%	55,07%
40	88,39%	86,81%	186,87%	152,73%	65,28%
41	108,39%	94,75%	77,48%	88,10%	77,32%
43	46,67%	84,42%	44,93%	87,34%	116,00%
46	121,68%	70,47%	67,69%	99,40%	77,70%
76	106,53%	105,79%	101,39%	96,28%	92,57%
108	86,23%	112,18%	126,75%	94,15%	92,80%
115	277,05%	262,43%	283,41%	475,00%	370,68%

132	76,19%	103,60%	101,18%	105,75%	157,72%
160	116,59%	115,54%	102,60%	99,60%	100,88%
166	57,58%	125,00%	125,00%	59,18%	47,01%
167	82,44%	86,79%	111,14%	83,50%	84,12%
178	147,29%	95,76%	84,12%	79,84%	64,50%
197	big	135,16%	Big	big	118,66%
232	big	big	82,10%	124,07%	72,18%
238	67,38%	100,82%	65,45%	77,19%	70,16%
239	69,17%	91,28%	115,74%	67,88%	69,07%
245	105,56%	94,74%	50,00%	66,27%	65,86%
246	107,05%	104,40%	76,93%	83,76%	83,74%
247	143,58%	173,38%	211,38%	192,81%	154,14%
251	106,03%	105,73%	101,63%	117,54%	113,13%
291	92,13%	108,01%	92,70%	91,02%	89,36%
294	100,07%	99,35%	80,71%	69,86%	72,68%
319	85,88%	99,74%	80,15%	82,28%	big
329	82,25%	103,71%	83,93%	79,78%	77,47%
Number of Efficient DMUs	13	10	7	10	11

Table 5 refers to the top 10 (with the greatest Efficiency performance) inefficient DMUs for the period 2006-2010. From this table it is observed that, with the exception of one DMU which almost continuously improved its Efficiency (107), many DMUs reduced their Efficiency (32, 65, 225, 255, 259, 276) while the others remain stable. Therefore, it is concluded that the implemented reforms have a negative effect on the operation of the top inefficient DMUs and do not contribute to the improvement of their Efficiency.

Table 5: Table of the top 10 inefficient DMUs for the period 2006-2010

DMU	2006	2007	2008	2009	2010
32	86,97%	84,29%	80,60%	79,76%	71,73%
65	89,76%	89,99%	85,91%	55,78%	46,11%
77	91,26%	86,14%	85,86%	80,66%	85,32%
107	79,32%	76,77%	86,03%	95,37%	87,86%
185	83,03%	84,05%	72,67%	78,01%	80,50%
202	86,75%	77,81%	81,01%	73,89%	80,15%
225	96,01%	44,44%	42,96%	45,21%	51,89%
255	89,06%	99,88%	83,47%	71,15%	76,01%
259	79,27%	73,38%	72,14%	70,87%	68,17%
276	87,74%	40,69%	43,76%	49,14%	44,59%

In Table 6 we see the ranking of the bottom 10 inefficient DMUs for the period 2006-2010, according to the Super – Efficiency model. It is observed that five DMUs increased their Efficiency (4, 74, 153, 322), while five retained their Efficiency (7, 59, 105, 176, 231, 266). This result is not considered satisfactory for the weakest in terms of Efficiency DMUs, given that the implemented reforms should have pushed these DMUs to raise their Efficiency considerably.

Table 6: Table of bottom 10 inefficient DMUs for the period 2006-2010

DMU	2006	2007	2008	2009	2010
4	41,39%	54,58%	49,51%	59,43%	53,11%
7	39,58%	38,96%	35,58%	40,30%	36,92%
59	36,66%	41,32%	32,13%	41,92%	39,85%
74	39,04%	42,55%	42,10%	64,01%	53,52%
105	19,29%	16,12%	16,54%	20,10%	20,56%
153	35,40%	42,56%	45,73%	51,78%	47,59%
176	42,58%	50,27%	44,76%	49,56%	45,12%
231	29,99%	42,42%	33,62%	39,09%	32,17%
266	42,97%	38,61%	46,94%	43,50%	41,99%
322	36,81%	45,03%	37,97%	40,81%	44,38%

Table 7 shows the performance of VRS relative Efficiency of efficient health units for the period 2006-2010. From this table it is observed that only four DMUs (115, 197, 247, 251) out of 30 maintain the Efficiency

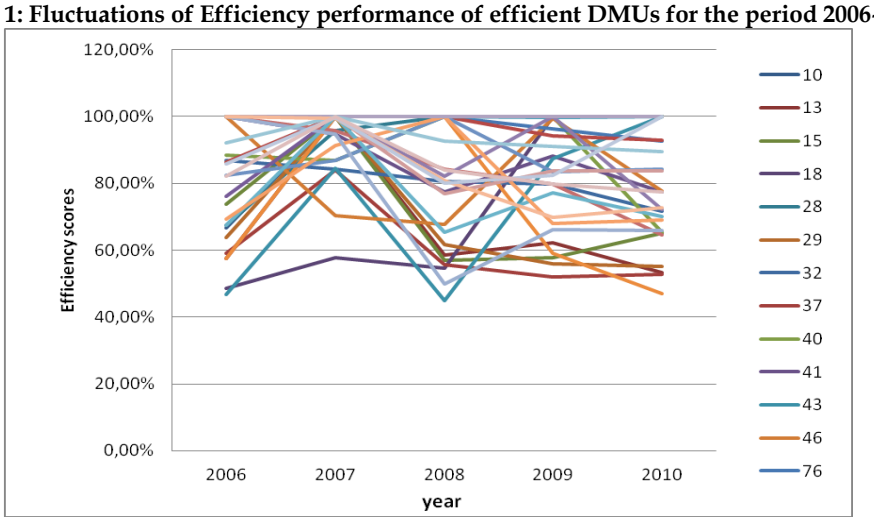
score of 100%, whereas four show a significant increase in their Efficiency, 10 proceed with their Efficiency decreasing, while the rest exhibit random fluctuations in their Efficiency. And from this table it is evidenced that the reforms have not exhibited any concrete results in terms of increasing the Efficiency of health units but on the contrary, there is a tendency of reducing the Efficiency of the efficient DMUs.

Table 7: VRS Table of relevant Efficiency of efficient Health Units for the period 2006-2010

DMU	2006	2007	2008	2009	2010
10	66,55%	100,00%	100,00%	100,00%	100,00%
13	57,52%	100,00%	58,59%	62,14%	53,34%
15	73,66%	100,00%	57,00%	57,78%	65,02%
18	48,72%	57,66%	54,72%	100,00%	100,00%
28	67,54%	95,76%	100,00%	100,00%	100,00%
29	63,72%	100,00%	61,69%	55,99%	55,07%
40	88,39%	86,81%	100,00%	100,00%	65,28%
41	100,00%	94,75%	77,48%	88,10%	77,32%
43	46,67%	84,42%	44,93%	87,34%	100,00%
46	100,00%	70,47%	67,69%	99,40%	77,70%
76	100,00%	100,00%	100,00%	96,28%	92,57%
108	86,23%	100,00%	100,00%	94,15%	92,80%
115	100,00%	100,00%	100,00%	100,00%	100,00%
132	76,19%	100,00%	100,00%	100,00%	100,00%
160	100,00%	100,00%	100,00%	99,60%	100,00%
166	57,58%	100,00%	100,00%	59,18%	47,01%
167	82,44%	86,79%	100,00%	83,50%	84,12%
178	100,00%	95,76%	84,12%	79,84%	64,50%
197	100,00%	100,00%	100,00%	100,00%	100,00%
232	100,00%	100,00%	82,10%	100,00%	72,18%
238	67,38%	100,00%	65,45%	77,19%	70,16%
239	69,17%	91,28%	100,00%	67,88%	69,07%
245	100,00%	94,74%	50,00%	66,27%	65,86%
246	100,00%	100,00%	76,93%	83,76%	83,74%
247	100,00%	100,00%	100,00%	100,00%	100,00%
251	100,00%	100,00%	100,00%	100,00%	100,00%
291	92,13%	100,00%	92,70%	91,02%	89,36%
294	100,00%	99,35%	80,71%	69,86%	72,68%
319	85,88%	99,74%	80,15%	82,28%	100,00%
329	82,25%	100,00%	83,93%	79,78%	77,47%

Figure 1 shows the Efficiency performance fluctuations of efficient DMUs for the period 2006-2010. In this figure the trend of most DMUs to reduce their Efficiency becomes even clearer given that the DMUs, with the exception of the four DMUs 115, 197, 247, 251 of a total of 30, throughout the duration of the study period achieved an Efficiency performance of 100%, whereas 10 DMUs exhibit a reduction of their Efficiency (13, 40, 41, 46, 76, 166, 178, 232, 245, 329).

Figure 1: Fluctuations of Efficiency performance of efficient DMUs for the period 2006-2010



Therefore, the reforms did not increase the Efficiency of the DMUs during the studied period.

Table 8 shows the VRS Efficiency scores of the first 10 inefficient health units from 2006 to 2010. From this table, a reduction in Efficiency scores is observed particularly from the beginning to the end of this time period, for about 8 of the 10 DMUs. This demonstrates the negative impact of the implemented administrative reforms on the Efficiency scores during the studied period and at the same time the identification of the results of the Efficiency change when using the VRS model and when using the Super- Efficiency model.

Table 8: VRS Table of relevant Efficiency of inefficient Health Units for the period 2006-2010

DMU	2006	2007	2008	2009	2010
32	86,97%	84,29%	80,60%	79,76%	71,73%
65	89,76%	89,99%	85,91%	55,78%	46,11%
77	91,26%	86,14%	85,86%	80,66%	85,32%
107	79,32%	76,77%	86,03%	95,37%	87,86%
185	83,03%	84,05%	72,67%	78,01%	80,50%
202	86,75%	77,81%	81,01%	73,89%	80,15%
225	96,01%	44,44%	42,96%	45,21%	51,89%
255	89,06%	99,88%	83,47%	71,15%	76,01%
259	79,27%	73,38%	72,14%	70,87%	68,17%
276	87,74%	40,69%	43,76%	49,14%	44,59%

Figure 2 shows the fluctuations in the Efficiency performance of the first 10 inefficient DMUs during the years 2006-2010. The decrease in Efficiency for DMUs 32, 65, 77, 222, 225, 255, 259, 276 (80% of the total) can be observed. From this reduction in the Efficiency of the DMUs during the period being studied, it is concluded that the Government's implemented reforms had a negative effect on the Efficiency performance of the first inefficient DMUs. So rather than push these DMUs to reach the Efficiency level, a profound decrease in Efficiency was caused distancing these DMUs from the Efficiency level, which is an effect totally opposite from the anticipated one.

Figure 2: Fluctuations in Efficiency performance of the first 10 inefficient DMUs

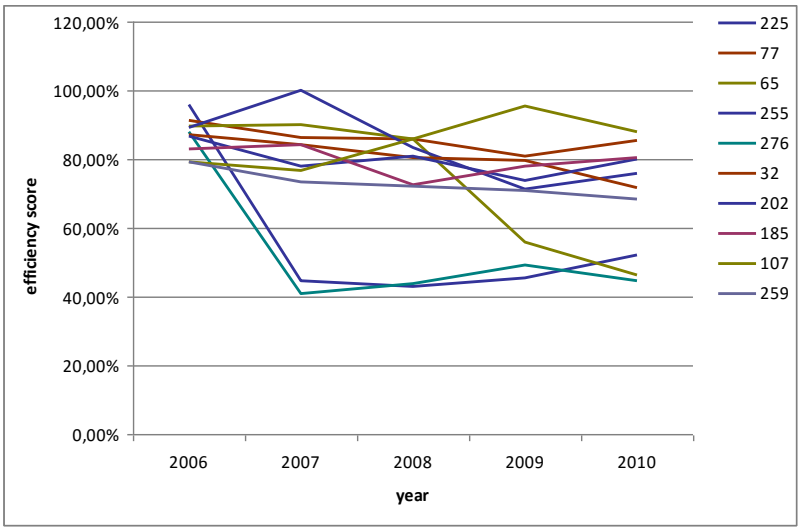


Table 9 shows the VRS relative Efficiency of the last 10 inefficient health units from 2006 to 2010. Note that out of a total of 10 DMUs, 5 of these (4, 74, 153, 176, 322) increased their Efficiency, while the remaining 5 maintained their Efficiency almost stable (after interim fluctuations). It is concluded that the implemented reforms had little positive effect on the Efficiency score of the last DMUs, so the success of the reforms is only slight in this group of DMUs.

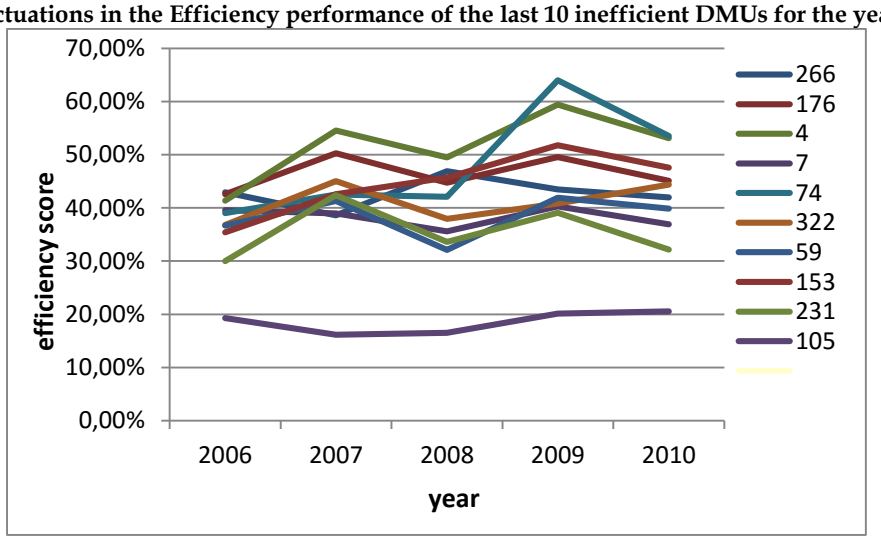
Table 9: Table of VRS relative Efficiency of the last 10 inefficient DMUs for the years 2006-2010

DMU	2006	2007	2008	2009	2010
4	41,39%	54,58%	49,51%	59,43%	53,11%
7	39,58%	38,96%	35,58%	40,30%	36,92%
59	36,66%	41,32%	32,13%	41,92%	39,85%
74	39,04%	42,55%	42,10%	64,01%	53,52%
105	19,29%	16,12%	16,54%	20,10%	20,56%
153	35,40%	42,56%	45,73%	51,78%	47,59%

176	42,58%	50,27%	44,76%	49,56%	45,12%
231	29,99%	42,42%	33,62%	39,09%	32,17%
266	42,97%	38,61%	46,94%	43,50%	41,99%
322	36,81%	45,03%	37,97%	40,81%	44,38%

Figure 3 shows a graphical illustration of the fluctuation of the Efficiency performance of the DMUs during the years 2006-2010. We observe the relative improvement in the Efficiency of 5 of the last 10 inefficient DMUs, which highlights the slightly positive effect of the implemented reform in this group of DMUs and their improvement which brings them up to the Efficiency level. However, the problem of non-improvement of the relative Efficiency of the last 5 DMUs is observed, although they are in the group of the last inefficient DMUs, thus bringing back the failure to meet the reform goals.

Figure 3: Fluctuations in the Efficiency performance of the last 10 inefficient DMUs for the years 2006-2010



From table 10, the following are noted: the efficient DMUs are 13 in 2006 (a percentage of 12.38%), 18 in 2007 (a percentage of 17.14%), 14 in 2008 (a percentage of 13.33%), 10 in 2009 (a percentage of 9.52%) and 11 in 2010 (a percentage of 10.47%). There is a constant to slight downward trend in the number of efficient DMUs. The total Efficiency performance stands at 66.12% in 2006, 73.10% in 2007, 65.06% in 2008, 67.88% in 2009 and 64.26% in 2010. There is therefore a constant to slight downward trend in the percentage of total Efficiency performance. Therefore, the realised administrative reforms have not resulted in increased Efficiency of the administration during the observed period, given that the overall Efficiency performance is decreasing.

Table 10: Efficiency score of Efficient DMUs (years 2006-2010)

Year	2006	2007	2008	2009	2010
Number of Efficient DMUs	13	18	14	10	11
Percentance of Efficient DMUs	12,38%	17,14%	13,33%	9,52%	10,47%
Total Efficiency Percentance	66,12%	73,10%	65,06%	67,88%	64,26%

Table 11 shows the Efficiency rating of the DMUs under consideration for the year 2006 and the weighting factors which have been linked to the DMU multiplied by the same inflows and outflows (absolute values of the weighting factors so that they are comparable).

From table 11 we can see that the solution is oriented to the maximum value for certain factors and this is expected since a certain freedom applies to the results, so each DMU is solved as to the importance of the inflows or outflows with the best performance. It is noted that I1 received the highest inflow scores, while O2 receives the highest outflow score, indicating the primary role of these coefficients in their effect on fluctuation of Efficiency.

Table 11: VRS score of Efficient DMUs for the year 2006 (model X) and importance factors by reduction

DMU	Score	I1 {I} {V}	I2 {I} {V}	I3 {I} {V}	O1 {ON} {V}	O2 {O} {V}
41	100,00%	0,02	0,98	0	0,99	0,01
46	100,00%	0	1	0	0,16	0,84
76	100,00%	0	0,89	0,11	1	0
115	100,00%	0	0	1	0	1

160	100,00%	0,25	0,75	0	1	0
178	100,00%	1	0	0	1	0
197	100,00%	1	0	0	0	1
232	100,00%	0	1	0	0,85	0,15
245	100,00%	1	0	0	0,35	0,65
246	100,00%	1	0	0	1	0
247	100,00%	1	0	0	1	0
251	100,00%	0	1	0	1	0
294	100,00%	0	0,65	0,35	1	0

4. Conclusions

This paper is a comparative study of the Relative Efficiency of Health Units over a five-year period preceding the start of the Greek Economic Crisis, taking into account the influence of implemented reforms undertaken by the Greek Government during this period, in order to increase Efficiency by eliminating inefficient practices and inefficiencies in the field of Health Units. Using free software, we perform the basic mathematical DEA's BCC and Super-Efficiency models, for Health Units of the Greek Health System (Public Sector). The results are presented in categories and graphic depiction is used in order to draw conclusions about the impact of implemented reforms on the change of the Efficiency of healthcare units during the period under consideration. A new application for the change of the Relative Efficiency of DMUs of the organisations which was developed for this purpose is used in this paper in order to extract easier and more specific conclusions. The change of Total Relative Efficiency proceeds randomly with a slight decrease during the studied period. The number of efficient DMUs shows a slight downward trend over the years. Many efficient DMUs exhibit random fluctuations in their Efficiency in the observed period. From the inefficient DMUs, as compared to those that show the greatest Efficiency scores, many of them remain stable regarding their Efficiency scores, whereas others exhibit significant decline in their Efficiency scores. Regarding inefficient DMUs occupying the last places in terms of Efficiency scores, an increase of the Efficiency scores is observed in some of them, while in others the scores are stable. The results of the study show no particular upward trend in the Efficiency scores of the DMUs participating in the study during the observed period, but on the contrary a random fluctuation with a slight downward trend of the Efficiency score is noted. This is interpreted negatively for the success of the reforms implemented by the Government aiming to increase the Efficiency of the DMUs, since no such increase has been achieved, but on the contrary a decline in the Efficiency of certain DMUs and a random fluctuation of the Efficiency of other DMUs has been observed. Therefore, the implemented reforms were unsuccessful as to their outcome. The limitation of the research is that the study refers to Public Health Units and not Private ones, so the conclusions cannot be extended to the Private Sector which operates on different criteria from the Public Health Sector. There is no geographical restriction on the investigation, but this one regards Public Health Units throughout Greece. The study leaves room for further research on the efficiency of Private Health Units during a period of Economic Crisis.

This study leaves room for further study in other Public Sector bodies as to the change in relative Efficiency in a period before an Economic Crisis and the integration of the results into a comprehensive Crisis Management framework.

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