Healthcare Management
Comparison of efficiency between hospitals

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I hereby declare that the work submitted is mine and that where I have made use of another’s work, I have attributed the source(s) according to the Regulations set in the Student’s Handbook.

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Abstract

This dissertation was written as part of the MSc in Strategic Product Design at the International Hellenic University.

In the modern society of consolidation and rapid change in the healthcare system in Greece, it is paramount that the healthcare centers ensure that they offer effective, efficient and high-quality services. One of the most important components to healthcare managers is the capability to benchmark in all facets of hospital performance with rival hospital centers. Over the last few decades, there were various approaches which have been used to measure the quality of healthcare.

This research paper will use data envelopment analysis (DEA) to compare the efficiency of healthcare services along a major urban and a major suburban/regional hospital. Although the method has been used in government units, and non-profit companies it has not been fully utilized in healthcare centers.

Taking that into consideration, there is a need to carry out more research on the effectiveness of the DEA in healthcare centers. This research paper will provide good performance methodology and comprehensively explain the use and effectiveness of DEA.

Keywords: Data Envelopment Analysis, Healthcare, Benchmarking

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Introduction

In the modern society of consolidation and rapid change in the healthcare system in Greece, it is paramount that the healthcare centers ensure that they offer effective, efficient and high-quality services. One of the most important components to healthcare managers is the capability to benchmark in all facets of hospital performance with rival hospital centers (Al-Shayea, 2011). When healthcare centers benchmark, they develop their delivery of services and they ensure that they offer effective and efficient services. Apart from benchmarking, the other important aspect that healthcare managers focus on is distribution of resources in the healthcare facilities. Some of the examples of competence include practical efficiency focusing on effective use of resources in cost efficiency and creating outputs. Other types of efficiency which are considered include allocative and managerial efficiency (Kontodimopoulos, et al., 2006). Measuring competence enables the need for optimization-based methods to access the industrious units.

Over the last few decades, there are various approaches which have been used to measure the quality of healthcare. Some of the methods which have been used include constant quality improvement (CQI) and total quality management (TQM) (Lovaglio, 2012). Apart from offering certification and accreditation processes, the approaches have been used to quantify the performance of health buildings to assess the National Health Systems. For instance, the global agencies have always focused on three major dimensions which are customer satisfaction, effectiveness and efficiency. However, Donabedian in (Lovaglio, 2012) argued that the quality of healthcare is determined by three major components which include structure (policies procedures, system of care and organization, licensure, safety, physical attributes, and accessibility of service). The second important component is process (preventive care which includes complications, accuracy of diagnosis, screening for disease, timeliness, and appropriateness of therapy) (Lovaglio, 2012). The third component is clinical outcome which refers to the technical result of specific treatment episode or diagnostic procedure. Of all the models used, DEA has been viewed as one of the accurate models for measuring efficiency.

Hence, the research will use data envelopment analysis (DEA) to compare the efficiency of healthcare services along a major urban and a major suburban/regional hospital. DEA refers to a mathematical programming technique which was developed by Rhodes, Charnes, and Cooper for evaluating the efficiency for non-profit companies (Huang & McLaughlin, 1989). DEA method is one of the most effective methods because it can handle multiple outputs and inputs concurrently. Additionally, DEA can create relatively efficient information which is not possible with other methods including the source and amount of relative inefficiency in decision units. Although the methods have been used in government units, and non-profit companies it has not been fully utilized in healthcare centers.

Taking that into consideration, there is a need to carry out more research on the effectiveness of the DEA in healthcare centers. This research paper will provide good performance methodology and comprehensively explain the use and effectiveness of DEA. From the research conducted in the past few decades, DEA is one of the best approaches which can be used by healthcare managers (Al-Shayea, 2011).
The method is effective because it can assess relative performance in both inter and intra departments. The data that are obtained by the healthcare managers can be an effective guide for organization and department improvement.
Hospital Benchmarking

Over the years, there has been raised attention on merging mechanical aspects such as healthcare workforce and governance with dealings of outcome to ascertain the value of service offered. Due to this concern, the Institute of Medicine defined quality of service as the degree to which health services for populations and individuals improve the probability of the looked-for health outcomes and work hand in hand with the professional knowledge (Lovaglio, 2012). The definition has been helpful and has confirmed to be useful and robust in design of practical methods to quality improvement and assessment (Lovaglio, 2012). The process of care raises the likelihood of desired outcomes of patient and reduces the probability of the undesired outcomes. Benchmarking is one of the techniques which can be used to increase the effectiveness in a healthcare center.

According to Lovaglio (2012) benchmarking refers to collaborative and continual discipline of comparing and measuring the results of key work procedures with those of the best performers when assessing organizational performance. There are two types of benchmarking which can be used to assess quality performance and patient safety. They are internal and external/competitive benchmarking (Lovaglio, 2012). Internal benchmarking focuses on identifying the best practices within an organization and comparing them with the current practice over a specified period. Also, it involves comparing different departments in the same healthcare center. Although internal data is easily accessible, collection of baseline data will require large amount of data for effective comparison. Additionally, the failure to adjust for methodological changes, healthcare, and patient may result in erroneous conclusions.

External or competitive benchmarking refers to using competitive data between companies to identify improvements and judge performance that is facilitated to the overall organization achievement. The major challenge for competitive benchmarking is accounting for the differences in surveillance methodologies and patient risks (El-Saed, et al., 2013). The primary aim for internal and external benchmarking is to continually improve the healthcare by demonstrating weaknesses and strengths, assessing the value of interventions intended, and stimulating the competitiveness. Using benchmarking to collect data is effective because data can be obtained by using standardized definitions and similar data collection methods in a large population size.

Additionally, benchmarking is a concept which has been used to access hospital performance and ensure that the process is improved. In a research carried out by (World Health Organization, 2003) six domains which are patient centeredness, patient safety, responsive governance, clinical effectiveness, production efficiency, and staff development were used in the benchmarking system to improve the efficiency of service delivery. According to the study collected for clinical indicators, the effectiveness of service delivery can be done by observing the information obtained through experiential and observational data. Patient safety is one of the concepts which is used to determine the quality of service which is delivered. When patients are assured of their safety they are willing to visit a healthcare center often. The Institute of Medicine defines patient safety as the inhibition of harm to patients.
Delivery of safe services to patient involves averting errors, learning from errors, and emphasizing on a culture of safety.

Some of the factors that the healthcare centers can consider when benchmarking includes learning, patient-centered care, leadership, communication, teamwork, and evidence-based care (Stavrianopoulos, 2012). In leadership the researchers must learn that healthcare environment is at high risk and it should seek to align with the company’s mission/vision, and staff competency. If there is no effective leadership, there is a major issue in the creation of a safe culture. Teamwork is another important component to focus on because the healthcare professionals always deal with complex technologies and treatments which require strong efforts towards application of collaboration and teamwork (Stavrianopoulos, 2012). In evidence-based care the focus should be coming up with practices which are based on evidence. The other important component is communication which means an individual staff should have the right to speak up on behalf of the patients. Ensuring that feedback is provided builds openness and trust. Learning is a crucial component which means the healthcare professionals should be ready to learn from their faults and pursue new chances for performance enhancement (Stavrianopoulos, 2012). Creating a just culture is also paramount because every individual must be accountable for their actions. The healthcare centers must focus on patient-centered care because a patient acts as a liaison between the community and hospital. The factors mentioned above can be used for external benchmarking.

It is the patients manager’s role to ensure that they provide quality services to the patients. Apart from benchmarking, the healthcare manager is supposed to focus on other important aspects which are patient satisfaction and clinical process quality. Hospitals in Greece use benchmarking techniques to combine both cost and operational efficiency estimates. Additionally, benchmarking is effective because it facilitates the assessment of efficiency and productivity of hospitals and uses multiple resources to give rise to multiple products. The DEA promotes use of benchmarking because of its efficiency in all the operational decision-making processes. Benchmarking can be applied in different perspectives.

**Efficiency Reporting**

Over the years, extensive research has been done on hospital competence. One of the areas of focus has been scale and technical efficiencies of hospitals. Technical efficiency has been used to measure whether a prolific unit is making use of minimum possible measure of resources (Giancotti, et al., 2017). The evaluation of technical efficiency is analyzed through identifying the relationship between inputs such as hours of work of the healthcare professionals and hospital beds. The output approach looks at medical outpatients and the number of ordinary admissions (Giancotti, et al., 2017). The technical efficiency score depends on operational scale which can be inappropriate that is too small or large.

The economic crisis of 2009 in Greece affected the heath sector. Before the economic crisis, the health expenditure between 2003 and 2009 had increased because of corrupt systems. The total expenditure increased from 8.5 % of GDP to 10
% in 2009 and by 2012 the expenditure has decreased to 9.1%. Moreover, the general government spending was also affected as it rose from 58.7% to 69.3% in 2003 and 2009 respectively (Boutsioi, 2010). The pharmaceutical sector which affects the health sector also rose with more than 76% spending. The economic crisis leads to reduction of healthcare spending by 9.1% of the GDP. The inability to control expenditure use was due to uncontrolled resource use and the constant subsidies which were used to cover deficits by hospitals and Society Security Fund (SSF) (Boutsioi, 2010). Additionally, the operating expenses excluding wages and salaries increased. This was due to pharmaceutical policy reforms, streamlined procurement procedures, and horizontal cuts applied by the Ministry of Health. Some of the operating expenditures which increased in the hospitals include security, consumables, and overheads. The cleaning services increased by 16%, in 2010 and 24% in 2011. Also, the security services have increased by 23% in 2010 and by 27% in 2011 (Boutsioi, 2010).

Figure 1: Key Expenditure Indicators

Due to the increase in expenditure, efficient provision of quality services in the healthcare sector has been one of the major controversial issues. Hence, a substantial volume of literature has focused on exploring the relationship that exists between inputs and outputs in healthcare centers through production functions. One of the methods that have been used by researchers over the years is DEA analysis (Boutsioi, 2010). The researchers who have used this method state that there is a considerable space for improvement. DEA has been viewed as the most effective methods because it can be used to measure the scale and mechanical competences. Additionally, the efficiency in a hospital can be analyzed by looking at the comments and opinions.
expressed by hospital administrators, Greek authorities, policy makers, and trade unions.

The Greek Healthcare System

The understanding of Greek healthcare system forms the basis of this study. There are various notable characteristics of the Greek NHS. One of the major characteristic is its decentralized structure. The establishment of Greek NHS in 1983 focused on the formation of robust regional healthcare authorities which transfers a wide spectrum of managerial tasks (Fragkiadakis, et al., 2013). Moreover, the establishment act of the Greek NHS introduced a regional structure which allowed local managers to play a crucial role in formulating proposals to address local needs and determine responsibilities (Fragkiadakis, et al., 2013). Nevertheless, the policy was not applied fully making the healthcare system to fully depend on the central government especially for funds.

There were also reform interventions in 2001 and 2003 which lead to the launch of an institutionally, explicit and controlled process of configuring the regional welfare and health system, conveying regional administration with tasks for operational and strategic decisions. The Ministry of Health took up the role of policy development at the national level (Fragkiadakis, et al., 2013 ). When the law was implemented, there were over 17 local administrative units which were started. However, by 2004 the reform became inactive when a new legislative was passed in 2005. Finally, in 2007 a new managerial structure was presented which was founded on seven district regional health administrations (RHAs) (Fragkiadakis, et al., 2013 ). Greek NHS merges both public and private healthcare services, with the public sector playing central role. The private sector primarily focuses on offering primary care services. On the flip side, the public hospitals cover approximately 70% of the total number of beds.

Additionally, through the public social insurance funds or the central government, public financing caters for the total health expenditure. Research conducted by World Health Organization shoes that the health expenditure per capita improved from $920 to $3,000 in 2000 and 2008 respectively. Later it decreased to $2,730 in 2010 (Fragkiadakis, et al., 2013). Greece is identified as one the countries with the maximum expenditure on pharmaceuticals in OECD.

The Greek NHS has handled some of the major problems in financing, organization, and the quality of the provided services. The other major problem that the sector has faced over the years is Economou which emphasizes on various factor. For instance, lack of well-defined funding policies and absence of cost-containment measures. Additionally, the healthcare lack incentives to advance their performance in the public sector (Fragkiadakis, et al., 2013). Also, they face unequal supply of health resources. Lack of coordination and planning is another factor that the healthcare centers have faced over the years. The other problems include irrational reimbursement and pricing policies, and oversupply of physicians.

The Greek NHS has faced various inefficiencies over the years. One of them is remuneration and payment of the health service providers such as the doctors.
According to Abel-Smith in (Boutsioli, 2010) one of the way of ensuring that healthcare providers provide efficient services is providing incentives. In Greece, the healthcare professionals receive their payment through monthly salaries. Such kind of payment does not promote incentives which have been one of the major causes of corruption in the healthcare centers (Boutsioli, 2010). Though the doctors’ salaries doubled in 1983, that fact did not reduce the illegal practices such as illegal practice of private medical services, and the concept of under table payment. Additionally, although the number of healthcare practitioners that is administrative staff, paramedical personal, nurses, and doctors; there is still a need for more healthcare practitioners. Most of the doctors prefer working in two major cities Thessaloniki and Athens, which means that the other small cities do not get the healthcare service required due to shortage of healthcare personal (Malik, et al., 2018). Lack of enough personnel in the rural areas is one of the major reasons mentioned for underutilization of hospital beds.

The Greek healthcare system is divided into three subsections which are discussed below;

**Primary care**

The primary care is primarily provided by the national healthcare system. It has about 180 health centers which offer rehabilitation, precautionary and therapeutic services for the outpatient department in the public hospitals and rural population. The other providers for primary care are the social security foundation which has its health centers, local authorities, city health departments, and local authorities. The NHS has always strived to upsurge admission to primary care and decrease influx of patients from rural to urban. However, due to financial constraints, under staffing and organizational glitches they are incapable to meet the expected standards.

**Secondary and Tertiary Care**

Secondary care is provided by both public and private sectors. Hence, the borderline between secondary and primary care is insignificant. The absence of the referral system makes a patient to freely refer themselves to the hospital outpatient department as the initial point of contact. Areas which have more specialized services entice patients from the nearby districts. Districts which are near Thessaloniki and Athens have the largest flow of patients. This is due to the incapability of some district general hospitals to deliver dedicated tertiary care.

**Hospital Health Centers (HHC)**

HHCs are small scaled hospitals with less than 100 beds. They are in either remote mainland areas, small islands, or serve a population which does not exceed 20,000. They take up the responsibility of secondary and primary care, but they are supposed to address preventive medicine issues. There services involve public health advancement and health education actions which involve the local communities. The services which they provide include hygiene for instance population screening, pap-tests, and hygiene education especially in learning institutions. Most of the HHCs were constructed in the mid-1900s when the access to large hospitals was hard.
Literature Review

Hospital Efficiency

The increased hospital deficit and public health spending has led governments to formulate legislations to transfer resources. Efficiency dimension has confirmed to be one of the most effective and adaptable tool for policy making, supportive decision, and healthcare management. One way that can be used to measure competence in a hospital is the input/output context. The evaluation of efficiency on the output/input refers to the assessment of the rare input resources (staff, beds, suppliers, costs) and their conversion into output (number of laboratory tests, and patients) (Fragkiadakis, et al., 2013). Researchers have used several non-parametric and parametric econometric/statistical methods to measure efficiency. One of the approaches used is the data envelopment analysis. Worthington cited in (Fragkiadakis, et al., 2013) states that the non-parametric nature of DEA which is founded on programming models offers flexibility on assortment of outputs and inputs in a multidimensional context compared to parametric methods which rely on a single output.

DEA models increase efficiency in selection of inputs and outputs making it effective in public sector where the maxims of profit expansion are not valid. Additionally, the DEA models do not need the overt functional relationship that exists between outputs and inputs. The DEA method promotes identification of sources of incompetence for each distinct hospital. According to O’Neill cite in (Fragkiadakis, et al., 2013) DEA is more effective in managerial decision making while parametric methods are valuable in policy analysis.

Due to its attractive features Fragkiadakis, et al. (2013) assert that DEA has been one of the most effective methods used in estimating the relative efficiency in hospitals in Greece as well as in Europe and other parts of the world. Hollingsworth (2008) provided a review of 317 published papers on the effective methods for measuring efficiency in healthcare. According to Hollingsworth’s research, there is an increased utilization of the parametric methods such as the stochastic frontier analysis. However, according to the results of the research, 75% of the published papers preferred DEA.

Further research conducted by Mitropoulos, et al. (2013) showed that there are two major approaches which are used to measure competence in healthcare centers. The first one is the stochastic frontier approach which imposes a functional form and allows calculation of errors on the data. On the flip side, Mitropoulos, et al. (2013) refers DEA as a non-parametric approach which permits calculation of multiple outputs and inputs. Mitropoulos, et al. (2013) supports the fact that DEA is more suitable for study of public sector actions. Furthermore, the DEA framework is effective because it offers a logical tool for determining ineffective and effective performance as the initial point for encouraging theories on best practice behavior.

Methods of Benchmarking

Benchmarking is a process that is built upon gap identification, change in the organization process, and performance comparison. Further Rough, McDaniel and Rinehart (2010) define benchmarking as the process of discovering and employing the
best practices. Benchmarking is an important concept in the healthcare centers because it enables hospitals to satisfy patients’ needs for quality and effective services by establishing new goals and standards. According to Watson cited in (Kay, 2007) the three principles of benchmarking include continuous improvement, customer satisfaction and maintaining quality. Benchmarking studies are time sensitive and perishable that is why there is a need for continuous benchmarking for improved performance.

Benchmarking is a nonstop procedure that reassures the use of Plan-Do-Study-Act (PDSA) cycles. The first phase which is the planning phase focuses on front decisions such as selection of processes/purposes to benchmark. In do, one focuses on self-study to describe the selection procedures using documenting business practices and metrics (Rough, et al., 2010). The study involves comparing the findings through gap analysis to know whether there are positive or negative gaps which exists in the company. Action means coming up with strategies to eliminate the negative gaps or maintaining the positive gaps.

According to Kay (2007) benchmarking process can be detached into two that is external and internal benchmarking. Generic, competitive and functional benchmarking is classified under external benchmarking. The process for benchmarking for each category is the same the only difference is to whom it is to be benchmarked. The benchmarking methods are discussed extensively below.

**Internal Benchmarking**

All the benchmarking processes start with internal benchmarking because a health center must examine itself to act as a baseline for comparison with others. Internal benchmarking covers two ways which are sharing opinion and communication between departments in the same organization (Rough, et al., 2010). When one department in a health center has better performance, the other departments can learn from that department. There are various advantages of benchmarking with include capability to deal with associates who share common systems, cultures, and language. Hence, the outcome of internal benchmarking is accessible quickly.

**External Benchmarking**

External benchmarking needs comparison of external organizations to determine new services, products, methods, and ideas. External benchmarking provides an opportunity for learning from the best experiences and practices from others. In the healthcare center, external benchmarking provides an effective management tool for determining the time is spent on several cognitive works. Also, it provided an opportunity to reduce costs (Kay, 2007). Additionally, it facilitates assessment of initiatives by comparing their effectiveness with comparable efforts in similar healthcare centers. External benchmarking is important because it determines the appropriate steps towards cost reduction targets including service utilization improvement, supply expenses, and labor expenses.
**Competitive benchmarking**

It denotes to direct assessment with the competitors. This is one of the most complex types of benchmarking because it is hard to achieve healthy cooperation and collaboration with direct competitors and obtain the primary information required. According to Cook cited in (Kay, 2007) competitive benchmarking is important because it creates a philosophy that values excellence, sharing best practices between partners and increases sensitivity to changes occurring in the environment. However, it is hard to acquire data from competitors and to apply the trainings learnt from them. Additionally, there might be a tendency to focus on factors that make a healthcare center distinctive instead of focusing on excellent performance in the organization.

**Functional Benchmarking**

It refers to comparative attempts and research and focuses on seeking world class excellent performance by looking at the best practices for businesses or companies operating in similar fields, having similar problems, or performing similar activities (Kay, 2007). For instance, comparing different healthcare centers in Greece will help the researchers to identify some practices which make some healthcare center more attractive to patients. Benchmarking based on function enables a healthcare center to improve its performance.

**Generic Benchmarking**

Generic benchmarking looks beyond data set and focuses more on the general processes. The major idea behind generic benchmarking is to introduce a new thinking in the healthcare in an organization (Kay, 2007). For instance, a healthcare center might compare their admission process rates with the check-in processes in the hotel chains which are performing better. Nevertheless, generic benchmarking is more likely to take long to complete and research outcomes may require modifications for the healthcare center to set their standards.

**Benchmarking in the Healthcare System**

From the mid late 1990s, benchmarking has been used in the healthcare centers to advance the quality of services in provision of health services. The common disadvantages which have been identified for using benchmarking in the healthcare centers include maintaining momentum and getting started (Rough, et al., 2010). One of the major focuses in healthcare benchmarking has been performance benchmarking which compares the performance levels to find gaps in performance. Process benchmarking involves identification of the root cases which results in attainment of superior performance. Patience skill benchmarking is also paramount because it focuses on meeting the patients’ expectations (Kozak, 2004).

The other important aspect of benchmarking is clinical practice benchmarking which involves allocation of best practice in clinical facets and structural comparison. Clinical benchmarking plays an instrumental role in an organization because it offers a quality valuation and continuous quality development approach which supports growth of the quality of care (Kay, 2007). Clinical benchmarking is an external method.
of benchmarking which looks at what standard of excellence is made of. Through the benchmarking process, there is networking which promotes exchange of information and generates a helpful culture.

Clinical practice benchmarking supports continuous improvement in the provision of quality of patient experiences and care. Benchmarking provides an opportunity to learn from others which facilitates the development of new practice and innovation to meet the patients’ needs and expectations rather than copying the good practices obtained (Ellis, 2004). Camp cited in (Kay, 2007) asserts that identifying what satisfies each customer improves on overall performance which benefits customers. Hence, benchmarking is not supposed to be viewed as an activity to obtain comparative data but should be accepted as a continuous quality improvement approach.

**DEA Method**

Data Envelopment Analysis (DEA) refers to a mathematical programming method which was conceptualized by Cooper, Rhodes, and Charnes in 1979. DEA is an effective method because it can handle multiple outputs and inputs concurrently (Huang & McLaughlin, 1989). Moreover, it can create relative competence information which is not obtainable from other methods which include the source of relative inefficiency in decision making units (DMU), and the relative efficiency ratio. Although DEA has not been extensively being used in service industry, it has been used in several studies. DEA utilizes nonparametric deterministic mathematical program to enhance the relative competence ratio in every DMU.

Furthermore, DEA uses current values for chosen multiple outputs and inputs simultaneously for each decision-making unit to create efficiency boundaries. Also, it compares the relationship which exists between different DMUs. It then generates a summary of scalar competence ratio for each DMU and recognizes the amount of inefficiency in each ineffective DMU (Birman, et al., 2003). One of the advantages of the DEA model is that each of the output and input can be measured self-sufficiently as a valuable unit without being transferred to a single metric provided that the identical variable is applied for every DMU (Huang & McLaughlin, 1989). Moreover, the DEA model uses input factors which significantly affect the output variables.

In the DEA model, there are only two main categories which are considered in healthcare analysis. This is evident because of the several studies which have been conducted over the years on the use of DEA. The researchers in the healthcare system have used the inputs and outputs. For instance, in a research conducted, the researchers stated that outputs refer to any product such as the patients served, and the services provided. Inputs refer to the aspects which affect the manufacture of the outputs. The input measures used in a research conducted by Huang and McLaughlin (1989) include percentage of users, nurse full time equivalents (FTEs), administrative FTEs, service area population, medical technician FTEs, and physician FTEs. After the analysis process, there was generation of scalar efficiency ratio which identified a group of proportional DMUs in each of the program.

According to Birman, Pirondi, and Rodin (2003) DEA provides the best approach to comparative performance valuation for healthcare managers. It is one of the powerful tools that healthcare managers can use for program development and
improvement (Al-Shayea, 2011). Birman, Pirondi, and Rodin (2003) assert that one can use DEA analysis to find the relative inadequacies for the medical systems. Thus, in a healthcare center, the researchers do not look at factors such as the way in which the doctors treat patients or the outcome of the treatment. However, they look at the $y$ number of doctors that a healthcare center takes to treat $x$ number of patients monthly. Hence, the usual output per input can be used to measure the relative inefficiency of the healthcare centers. Farrell cited in (Birman, et al., 2003) came up with the idea of quantifying the relative incompetence score as the ration of a single output and compared it with an output. Nevertheless, the doctors are not the only ones when considering the inputs (Birman, et al., 2003). Other inputs that can affect the outcome include electricity, medicine, nurses, review medical prescriptions, and fill out papers. Thus, in this case single input single-output system cannot work. Measuring the technical efficiency will require the researchers to adapt the multiple-input multiple-output system.

**Greek Health System**

Over the years, the Greek Healthcare system has gone through a process referred to as decentralization. The three phases are from 1923 to 1983, then from 1983 to 2001 that is when the National Health System was conceptualized then from 2001 to date (Athanasiadis, et al., 2015). The first phase which is dubbed before the National Health System was a period in which Greece experienced an influx of approximately 1,221,849 refugees who settled in the urban centers mostly Thessaloniki and Athens. Pomonis cited in (Athanasiadis, et al., 2015) states that the provision of healthcare services to the population needed the re-organization of the state. Thus, the Ministry of Hygiene and Social Welfare was conceptualized in 1992. Additionally, numerous new state hospitals came up (Moraitis, 2004).

Moreover, legislations such as the Legislative Decree 2592/1953 was established which facilitated the creation of a decentralized health system. Later, the Royal Decree 297/1953 was formulated to deal with spatial regionalization of the public health system in the thirteen regions in Greece (Athanasiadis, et al., 2015). However, in the 1950s Greece was a war-ravaged country and required institutional framework which was essential for management changes and administration (Athanasiadis, et al., 2015). Also, the lack of a well-defined economic policy made it hard for the policy makers to implement any significant change. This leads to the introduction of the second phase.

The second phase is dubbed as the initial stage of National Health System. This was the period between 1950s and 1960s which was characterized by restricted investment in the healthcare sector. However, in 1979 under the leadership of Sypros Doxiades who was the minister of health (Athanasiadis, et al., 2015), there was establishment of a legislative plan known as the ‘Measures of Health Protection’. There was a resource allocation process which was set within a budget which was established by the central government. Later, there was formation of the National Health System which was permitted by the Parliament in 1983 and enacted as an Act in 1997 (Athanasiadis, et al., 2015). The act promoted provision of healthcare services and ensured that there was equitable circulation of healthcare resources.
Administrative reorganization and decentralization of the healthcare was set to achieve geographical and social equity.

The need for immediate change in the healthcare system led to the introduction of the third phase which emphasized on the implementation of the decentralization process. There was an introduction of a new health modification which focused on regional organization of the National Health System (Athanasiadis, et al., 2015). Through the reform, there was creation of seventeen regional health systems. However, with time Greece faced a major financial crisis and it had to seek for support from the European Central Bank, the International Monetary Fund, and the European Commission (Athanasiadis, et al., 2015). Thus, the implementation of the decentralized system is still a major challenge in health policy agenda in Greece.

Furthermore, there has been an increase in expenditure in Greece Healthcare system. According to a research conducted in 2000, the total healthcare expenditure in Greece was 9.1% of the GDP (Souliotis & Lionis, 2004). Although the expenditure continuous to increase, Greece has come up with several strategies to modernize and improve the provision of healthcare services. For instance, the improvement of the Primary care was approved freshly. The Health Act strived to improve the quality of care through the implementation of the Regional Health Systems. Thus, there is a need to conduct more research to ascertain the effectiveness of the Greek Healthcare System.
Data and Methodology

Data

The data is going to be obtained from two hospitals; that is a suburban/regional and an urban hospital. The data will be drawn from the yearly report (year 2017) of each hospital in association with the department managers of each healthcare center. The hospitals have gone through a reorganization process as they adapted the new budgets set by the national government. Hence, the reports will be good source of information as the reports’ aim was to ensure that there was efficient management of resources and control costs. The hospitals have been in operation for long. Hence, by obtaining data from the hospital we will get substantial information which will help us in our research. Also, the sample size will be rather small and manageable to ensure that we have collected enough information so that we can get authentic results.

Figure 1: The figure below shows the output and input variables which will be used in this research process. The inputs represent the alternative costs contributing to the categories. The output represents the volume of the health service which is provided in every clinic.

The DEA tool will be used in this research for competence measurement. DEA is a tool which is applied in a set of standardized units which are referred to as Decision making units (DMU). DMUs aim is to maximize the unit of efficiency as it is defined through analyzing the sum of the weighted outputs over the sum of the weighted inputs. The major aim behind the method is to allow each of the unit to weigh the production outputs and inputs to attain maximum efficiency compared to the efficiencies given in the sample.

The efficient combination of input and output permitted by the technology results to the formulation of a fractional programming problem. The solution of the equivalent linear program looks at the set of the units which are viewed as efficient and the units which are viewed as inefficient. The determination of the best practice units facilitates the building of the best practice frontier which separates the inefficient units.

The technically efficient units are assigned a score less than 1. On the flip side, the technically inefficient ones are allocated a positive score of less than 1. The
percentage score of the inefficient unit can be obtained in one or two ways either output oriented or input-oriented efficiency scores. It is evident that DEA refers to a non-parametric method which is based on observed input-output combination of the units. One of the major advantages of the method is the combination of multiple inputs and outputs without a need for shared denominator for reference.

The most common model of DEA is one developed by Charnes, Rhodes and Cooper. The model was later modified by Cooper, Banker, and Charnes. The model formula is outlined below:

For each  \( DMU_p \quad p = 1,2,\ldots, \)

Maximize \( E_p = \frac{\sum y_{pi}w_i}{\sum x_{pj}v_j} \)

Subject to:
\[
\frac{\sum y_{ki}w_i}{\sum x_{kj}v_j} \leq 1 \quad \text{for} \quad k = 1,2,\ldots,K
\]

\( E_p = \text{Departmental Efficiency} \quad (p = 1,2,\ldots,K) \)

\( w_i \geq \varepsilon, \text{for} \quad i = 1,2,\ldots,I \)

\( v_j \geq \varepsilon, \text{for} \quad j = 1,2,\ldots,J \)

\( x_{kj} = \text{input value } j \text{ for } DMU_k \)

\( y_{ki} = \text{output value } i \text{ for } DMU_k \)

\( \varepsilon = \text{a small constant} \)

The main objective for using DEA in this case is to discover the efficiency frontier which can be molded by the combination of resources which enhance the amount of outputs which are shaped while at the same time minimizing the inputs. The health sector in Greece has faced a lot of challenges because of the insufficient resources required. Hence, looking for strategies to reduce the inputs will be of great advantage for the health sector. DEA encompasses simple output/input ratios through combination of multiple outputs and inputs and provides estimates for technical efficiency. Magnussen cited in (Fragkiadakis, et al., 2013) states that hospital can be technically competent if an increase in input necessitates a decrease in output. The DEA offers an orientation for benchmarking the competence of the effective decision-making units.
**Input and Output Specifications**

Selection of the inputs and outputs that define the multi-layered operation of the healthcare units is a vital factor to consider in assessing the competence status in a health center. O’Neill cited in (Fragkiadakis, et al., 2013) provided an all-inclusive categorization of multiple outputs and inputs. The methods involve six major categories which are costs, service offered, clinical staff, working hours, non-clinical staff and beds. The output consists of two categories which are patients, and hospital expenses. It is vital to emphasize on the sensitivity of the results to change the input-output specifications. When considering the overall efficiency, one can consider the cost and operational efficiency.

There is a criterion which should be followed when selecting the inputs and outputs. The outputs are supposed to capture all the performance measures and activity levels while the inputs are supposed to cover a wide spectrum of all the resources used. Additionally, both the output and input variables are supposed to constitute the set of factors which are like all the units under examination. The labor inputs in this case are going to be calculated by considering the number of staff in this case we will consider the hospital employees and the physicians. The other important input is the number of hospital beds. The output refers to the array of the healthcare services that improve the patients’ health. The DEA model in this case will be formulated as input-oriented because we will be dealing with public hospital where the hospital managers can only reduce the input usage instead of seeking output increment. For instance, in this case, the hospital expenses should be reduced. The DEA model is supposed to be a fractional linear program. Hence, to unravel the model, it must be transformed into a linear form to ensure that the methods of linear programming are used. Hence, maximizing a ratio or fraction, the relative value of the denominator and numerator are vital and not the individual values. Thus, one can achieve the effect of setting the denominator equal to the continuous and maximize the numerator.

Some of the DEA models which can be utilized in the process include BCC model, Slack-Based Model, and CCR model.

**CCR Model**

This was the first DEA model conceptualized by Cooper, Charnes, and Rhodes. If there are n DMUs, DMU1... DMU3... DMUn each of the DMU use an m inputs xij (i=1...m) dan comes up with s outputs yrj (r=1...s). The input weights vi (i=1, 2...m) and the output weight ur (Malik, et al., 2018). The DMUj can be evaluated on any trial. The efficiency of DMU can be answered by using the linear programming below.
The model above is run n times to identify the relative competence scores in all the DMUs. The DMU then selects a section of the output weights ur and input weights vi to maximize the efficiency score. The DMU is considered as efficient if it attains a maximum score of 1. If it is not less, then one the DMU is inefficient.

BCC Model

This model implemented the Variable Return to Scale and stands for Banker, Charnes, and Cooper. According to the model, the efficient frontier is formulated by the convex hull of the exiting decision-making units (Malik, et al., 2018). The envelopment form for BCC is:

\[
\begin{align*}
    e_o &= \max \sum_r u_r y_{ro} \\
    s.t. \quad &\sum_r u_r y_{ro} - \sum_i v_i x_{io} \leq 0 \\
                    &\sum_i v_i x_{io} - 1 \\
                    &u_r, v_i \geq 0
\end{align*}
\]

The BCC is different from CCR because of the additional convexity constraint. A DMU is BCC efficient if it has a maximum optimal solution of \(0=1 \lambda=1\) and \(\lambda\neq0\).

Slack Based Model (SBM)

The model represents the measurement efficiency:
The Si – and Sr + are slacks, Si – refers to input excesses dan Sr + stands for output variables. The optimum solution for SBM is 1, which can be attained when all the slacks are equivalent to zero. This is consistent with BCC and CCR models (Malik, et al., 2018).

\[
\begin{align*}
\min \rho & = \frac{1 - \frac{1}{m} \sum_i s_i^- / x_{io}}{1 + \frac{1}{n} \sum_r s_r^+ / y_{ro}} \\
\text{s.t.} \quad & \sum_j \lambda_j x_{ij} - x_{io} + s_i^- = 0 \\
& \sum_i \lambda_i y_{ri} - y_{io} - s_i^+ = 0 \\
& \sum_j \lambda_j = 1 \\
& \lambda_j, s_i^-, s_r^+ \geq 0
\end{align*}
\]
Implications of Empirical Findings

**DEA Analysis**

The data collected as shown in figure (1) was run through the DEA program.

<table>
<thead>
<tr>
<th>YEAR 2017</th>
<th>Major Urban Hospital</th>
<th>Major Suburban-Regional Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;G.Papanikolaou&quot; General Hospital Thessaloniki</td>
<td>Veroia General Hospital</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INPUTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff</td>
<td></td>
</tr>
<tr>
<td>Doctors</td>
<td>505</td>
</tr>
<tr>
<td>Nurses</td>
<td>491</td>
</tr>
<tr>
<td>Administrative/Other</td>
<td>481</td>
</tr>
<tr>
<td>Beds</td>
<td>622</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total operating cost</td>
<td>97.019.252,00 €</td>
</tr>
<tr>
<td>Staff cost</td>
<td>38.754.192,00 €</td>
</tr>
<tr>
<td>Pharmaceutical cost</td>
<td>21.596.515,00 €</td>
</tr>
<tr>
<td>Other medical costs</td>
<td>13.950.478,00 €</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OUTPUTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissions</td>
<td>50225</td>
</tr>
<tr>
<td>Inpatients</td>
<td>50446</td>
</tr>
<tr>
<td>Days of Hospitalization</td>
<td>162372</td>
</tr>
<tr>
<td>Surgical Operations</td>
<td>10043</td>
</tr>
<tr>
<td>Outpatient visits</td>
<td>118626</td>
</tr>
<tr>
<td>Emergency visits</td>
<td>68719</td>
</tr>
</tbody>
</table>

*Figure 1: Data*
A total of five (5) different DEA’s were performed in order to identify and measure efficiency from several aspects and assess the total efficiency of each healthcare center. Below, the table indicates the data that were taken into consideration for each analysis.

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEA 1: Total operational efficiency</strong></td>
<td></td>
</tr>
<tr>
<td>Clinical staff/ Doctors</td>
<td>Inpatients</td>
</tr>
<tr>
<td>Nurses</td>
<td>Surgeries</td>
</tr>
<tr>
<td>Administrative/Other staff</td>
<td>Outpatients</td>
</tr>
<tr>
<td>Beds</td>
<td>Emergency visits</td>
</tr>
</tbody>
</table>

| **DEA 2: Admissions efficiency** | |
| Clinical staff/ Doctors | Admissions |
| Nurses | Days of Hospitalization |
| Administrative/Other staff | |
| Beds | |

| **DEA 3: Outpatient treatment efficiency** | |
| Clinical staff/ Doctors | Outpatients |
| Nurses | Emergency visits |
| Administrative/Other staff | |
| Beds | |

| **DEA 4: Total cost efficiency** | |
| Total operating cost | Inpatients |
| Beds | Surgeries |
| | Outpatients |
| | Emergency visits |

| **DEA 5: Labor, Supplies and other cost efficiency** | |
| Staff cost | Inpatients |
| Pharmaceutical costs | Surgeries |
| Other medical costs | Outpatients |
| Beds | Emergency visits |
All DES’s are output oriented. An output oriented measure quantifies the necessary output expansion holding the inputs constant. The distance measure is Radial. This measure (a.k.a. Debreu-Farrell-measure, or “radial part” of the CCR/BCC measure) indicates the necessary improvements when all relevant factors are improved by the same factor equipropotionally.

Data Results

Total Operational Efficiency

The DEA 1 analysis focuses on total operational efficiency. The inputs considered in this case include clinical staff/doctors, nurses, administrative/other staff, and beds. The outputs include inpatients, surgeries, outpatients, and emergency visits. Table 1 below represents the effect of both inputs and outputs in the total operational efficiency in Veroia General Hospital and G. Papanikolaou" General Hospital Thessaloniki.

<table>
<thead>
<tr>
<th>DMU</th>
<th>&quot;G.Papanikolaou&quot; General Hospital Thessaloniki</th>
<th>Veroia General Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Clinical staff/ Doctors [I][V]</td>
<td>21.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>Nurses [I][V]</td>
<td>30.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Administrative/Other staff [I][V]</td>
<td>25.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Beds [I][V]</td>
<td>25.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Inpatients [O][V]</td>
<td>100.00%</td>
<td>24.00%</td>
</tr>
<tr>
<td>Surgeries [O][V]</td>
<td>0.00%</td>
<td>24.00%</td>
</tr>
<tr>
<td>Outpatients [O][V]</td>
<td>0.00%</td>
<td>21.00%</td>
</tr>
<tr>
<td>Emergency visits [O][V]</td>
<td>0.00%</td>
<td>32.00%</td>
</tr>
<tr>
<td>Benchmarks</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

From the analysis, we can see that G. Papanikolaou" General Hospital Thessaloniki is supposed to improve its inputs to improve its total operational efficiency. For instance, G. Papanikolaou" General Hospital Thessaloniki can attain its efficiency by increasing its clinical staff/doctors, nurses, administrative staff, and beds by 21%, 30%, 25%, and 25% respectively. On the flip side, the Veroia General hospital can use its present resources to attain better results with 24% improvement inpatient count and surgeries.

Admissions Efficiency

The DEA 2 analyzes admissions efficiency. The inputs considered in this case are clinical staff/doctors, nurses, administrative/other staff, and beds. The outputs are admission and days of hospitalization. Understanding the effect of inputs on admission efficiency enables the hospitals to consider what needs to be done to have the right resources to improve their admission capacity.
From the analysis, G. Papanikolaou General Hospital Thessaloniki is supposed to improve its inputs to improve its admission efficiency. For instance, it would be better to improve its clinical staff/doctors, nurses, administrative/other staff, and beds by 22%, 26%, 26% and 26% respectively, in order to reach the same results efficiently. On the contrary, Veroia General Hospital should get, with the same resources, 4% and 96% admissions and days of hospitalization respectively.

**Outpatient Treatment Efficiency**

The inputs applied in DEA 3 include clinical staff/doctors, nurses, administrative/other staff and beds. The outputs are outpatients and emergency visits. G. Papanikolaou General Hospital Thessaloniki has to maximize its inputs to offer better outpatient services. It has to improve clinical staff, nurse, administrative staff and beds by 21%, 26%, 27% and 27% respectively. On the other hand, Veroia General Hospital needs to maximize its inputs efficiency and result in 97% and 3% improvement in their outpatients and emergency visits by using the same resources.
Total Cost Efficiency

DEA 4 examines cost efficiency by considering inputs such as total operating costs and beds. The outputs are inpatients, surgeries, outpatients, and emergency visits.

<table>
<thead>
<tr>
<th>DMU</th>
<th>&quot;G. Papanikolaou&quot; General Hospital Thessaloniki</th>
<th>Veroia General Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>100,00%</td>
<td>100,00%</td>
</tr>
<tr>
<td>Total Operating Cost (I){V}</td>
<td>44,00%</td>
<td>100,00%</td>
</tr>
<tr>
<td>Beds (I){V}</td>
<td>56,00%</td>
<td>0,00%</td>
</tr>
<tr>
<td>Inpatients {O}{V}</td>
<td>100,00%</td>
<td>23,00%</td>
</tr>
<tr>
<td>Surgeries {O}{V}</td>
<td>0,00%</td>
<td>24,00%</td>
</tr>
<tr>
<td>Outpatients {O}{V}</td>
<td>0,00%</td>
<td>31,00%</td>
</tr>
<tr>
<td>Emergency visits {O}{V}</td>
<td>0,00%</td>
<td>22,00%</td>
</tr>
</tbody>
</table>

Both hospitals have managed to maximize their inputs in terms of total operating costs to offer services to their patients. Nevertheless, "G. Papanikolaou" General Hospital Thessaloniki needs to maximize its total operating costs and beds by 44% and 56% respectively to attain maximum benefits. Contrary, Veroia General Hospital can retain its inputs and still improve inpatients count and surgeries by 23% and 25% respectively.

Labor, Supplies, and Other Cost Efficiency

In DEA 5 the outputs and inputs are balanced. The inputs include staff cost, pharmaceutical costs, other medical costs, and beds. The outputs include inpatients, surgeries, outpatients, and emergency visits.

<table>
<thead>
<tr>
<th>DMU</th>
<th>&quot;G. Papanikolaou&quot; General Hospital Thessaloniki</th>
<th>Veroia General Hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>100,00%</td>
<td>100,00%</td>
</tr>
<tr>
<td>Staff cost (I){V}</td>
<td>22,00%</td>
<td>99,00%</td>
</tr>
<tr>
<td>Pharmaceutical cost (I){V}</td>
<td>22,00%</td>
<td>1,00%</td>
</tr>
<tr>
<td>Other medical costs (I){V}</td>
<td>26,00%</td>
<td>0,00%</td>
</tr>
<tr>
<td>Beds (I){V}</td>
<td>31,00%</td>
<td>0,00%</td>
</tr>
<tr>
<td>Inpatients {O}{V}</td>
<td>100,00%</td>
<td>20,00%</td>
</tr>
<tr>
<td>Surgeries {O}{V}</td>
<td>0,00%</td>
<td>20,00%</td>
</tr>
<tr>
<td>Outpatients {O}{V}</td>
<td>0,00%</td>
<td>17,00%</td>
</tr>
<tr>
<td>Emergency visits {O}{V}</td>
<td>0,00%</td>
<td>43,00%</td>
</tr>
<tr>
<td>Benchmarks</td>
<td>0,00%</td>
<td>0,00%</td>
</tr>
</tbody>
</table>

Both G. Papanikolaou" General Hospital Thessaloniki and Veroia General Hospital have to strike a balanced between its inputs and outputs for maximum delivery of their services.
Conclusions

The study above attempts to access the overall efficiency of Hospital A and B based on inputs and outputs using DEA software. The analysis was based on a comprehensive set of variables, inputs (staff, beds and costs) and outputs (admissions, inpatients, days of hospitalization, surgical operations, outpatient visits, and emergency visits). In every analysis from DEA 1 to DEA 5, “G. Papanikolaou” General Hospital Thessaloniki results were that it needs to improve its inputs so that it can attain maximum efficiency. On the flip side, Veroia General Hospital can use its own resources to improve efficiency with the same inputs. That means “G. Papanikolaou” General Hospital Thessaloniki is inefficient with its outputs, whereas Veroia General Hospital is inefficient with the resources used.
References


