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Investigating the Efficiency of Senior Secondary Schools: Evidence from Schools in the Greek region of Central Macedonia

Dimitrios Sotiriadis[1], Georgios Menexes[2], Constantinos Tsamadias[1]

[1]School of Environment, Geography and Applied Economics, Harokopio University, Athens, Greece
[2]Faculty of Agriculture, Forestry and Natural Environment, School of Agriculture, Aristotle University of Thessaloniki, Greece

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ABSTRACT
Purpose
This study examines the efficiency of Senior Secondary Schools, in the Region of Central Macedonia in Greece, using input-oriented Data Envelopment Analysis, with three inputs and two outputs variables. Data concern schools in urban, semi-urban/rural, for the school years 2007-08 (before the economic crisis) and 2010-11 (during the economic crisis).
Design/methodology/approach
In this study, Data Envelopment Analysis is applied under the Constant Returns to Scale (CRS) or Variable Returns to Scale (VRS) hypotheses. The study used a Senior Secondary Schools sample with stratified proportional sampling. This study's data collection has been accomplished with the help of the information systems and the databases maintained in every school
Findings
The empirical analysis revealed that the majority of schools were inefficient. The technical efficiency under constant returns to scale varies in interval [0.510-1] and [0.511-1], with average score being 0.729 and 0.827, for the school years 2007-08 and 2010-11, respectively. Under variable returns to scale varies in interval [0.521-1] and [0.516-1], with average efficiency score being 0.815 and 0.834, for the school years 2007-08 and 2010-11, respectively. The scale efficiency for 2007-08 varies in interval [0.673-1], for 2010-11 varies in interval [0.939-1], with average efficiency score being 0.897 and 0.991, respectively. During the economic crisis the performance of schools improved. Additionally, the schools in semi-urban/rural areas had on average higher efficiency than those in urban areas.
Research limitations/implications
Further research can extend this study. For instance, future studies could introduce additional input and output variables. Moreover, researchers might use a combination of available techniques such as bootstrapping to estimate the efficiency of schools over a longer period of time and after the economic crisis
Originality/value
To the best of our knowledge, this is the first study of the aforementioned issue for a region on the European Union's periphery one year before and one year during the economic crisis. The results are expected to provide insightful information for policymakers in order to better understand the performance of the schools and seek more appropriate solutions aiming at moving the sector forward. The proposal of this study is the establishment of an Observatory, authored by the Greek Ministry of Education, monitoring the diachronic data and measurements of the schools' efficiency.

1. Introduction

Over recent decades, a few methods have been developed to estimate the relative efficiency of production systems because their efficiency is crucial to the economic growth of countries or regions. The concept of efficiency (both technical and scale) is relative rather than absolute.
In the last few years, the two dominant approaches that have arisen are Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). Both assess the performance of decision-making units (DMUs) (Lee, 2011; Sav, 2012; McMillan and Chan, 2006; Kempekes and Pohl, 2006). SFA is a stochastic and parametric technique, and DEA is a deterministic and non-parametric technique. Both are considered frontier methodologies. This approach assumes a function for the relationship between inputs and outputs. DEA constructs

†Corresponding Author: Dimitrios Sotiriadis
E: jimsots@otenet.gr
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the production-possibility curve frontier function from available data using linear programming.

The two methods differ in their underlying assumptions. There are two ways to measure relative efficiency in terms of mathematical programming: The input-oriented (IO) model concerns input minimization while maintaining the levels of output, whereas the output-oriented (OO) model focuses on output maximization with the same quantity of inputs. According to the economics literature, *educational units* are systems that produce, accumulate, and diffuse human capital. They play an important role in socioeconomic development, employment, and social cohesion in the age of a knowledge society. Moreover, they use limited resources from the economy. DEA is considered a more appropriate method to evaluate the relative efficiencies of schools/DMUs (Cooper et al., 2011). The main framework of this method is to treat schools as production units that use multiple inputs and outputs. The method produces measures of schools' relative efficiency by deriving a frontier production function (efficiency frontier) and measuring the distance of observations to the frontier to obtain their efficiency scores.

In Greece, secondary education was established in the 19th century, and since then, it has become a field of successive legislative reforms. In the last four decades, it has been divided into the following two stages: a) compulsory, that is, "gymnasium" or middle or junior high school and b) non-compulsory, meaning "lyceum" or senior secondary school (SSS). Central Macedonia is one of the 13 regions of Greece, with an area of 18.811 km^2 (largest area in Greece) and the second in population with 1.874.590 residents (Hellenic Statistical Authority, 2011). It consists of the following seven prefectures: Thessaloniki, Serres, Kilkis, Chalkidiki, Pella, Pieria, and Imathia. It has a large urban center (Thessaloniki, with 622.240 residents) and six other cities that are capitals of the other prefectures. It also has many smaller cities and villages. It is the most representative region throughout Greece, because it has big urban centers, semi-urban and rural regions, and tourist and frontier regions.

In terms of education, Central Macedonia has 165 SSSs. There are two main types of SSS: the General Lyceum (60% of total schools) and the Vocational Lyceum (30% of total schools). However, there are also a few church, minority, intercultural, experimental, music, and evening schools (Regional Administration of Education of Central Macedonia, 2011).

The schools in our sample were all public. The Hellenic Data Protection Authority and the Ministry of Education prohibit public schools from keeping official data relevant to the financial, educational, and social level of the students' parents, as well as other sensitive student data, for example, health problems. Consequently, within the framework of the Greek educational system, is very difficult to assess the potential endogeneity of educational quality or overcome issues stemming from this fact (e.g., isolating the quality of specific public schools or estimating "value-added" models that allow students' initial ability and socioeconomic background, their school socioeconomic composition, or the gender of the students and their ethnicity. Hence, in public schools, all students are Greek and practically anonymous.

To obtain access to tertiary education, students must take national exams in pre-defined courses. The period 2007–2011 was chosen primarily because it was when Greece became a full member of the Eurozone (since 2001) and because in 2010, due to an economic crisis, it entered the Support Mechanism (European Commission, European Central Bank, International Monetary Fund). Thereafter, publicly funded sectors have been under pressure to use resources efficiently. A strict fiscal policy has been pursued, with a strong impact on school financing.

The purpose of this paper is to measure the relative efficiencies (technical and scale) of SSSs in Greece's Central Macedonian region. Furthermore, this study aims to classify the SSSs into groups of similar characteristics—that is, area of operation (urban, suburban, or rural), before or during the financial crisis—and to compare the results of the groups. To the best of our knowledge, this is the first study of the aforementioned issue for a region on the European Union's periphery for one year before and one year during the economic crisis.

The results of this paper are expected to provide more understanding of the efficiency of SSSs for educational managers and policymakers to find possible solutions to improve the performance of SSSs in Central Macedonia.

The rest of the paper is structured as follows: The next section offers a brief overview of various empirical studies. Section 3 applies DEA to measure the relative efficiency of each school. Based on efficiency measures, a cluster analysis is conducted. Finally, Section 4 presents concluding remarks and policy implications.

2. Review of Empirical Studies

In the empirical economic literature, a few studies have examined the efficiency of secondary education schools. In most of them, the DEA methodology is used. A few have used SFA methodology. The empirical studies use the following sets of inputs and outputs (see Table 1).

Inputs: X_1: the ratio of teachers to students, X_2: educational level of teachers, X_3: the type and size of the school, X_4: teaching hours per week, X_5: educational or economic level of students' parents, X_6: the cost of the school, X_7: the number of students per school, X_8: students' performance in specific courses, X_9: the percentage of students studying more than 10 hours per week, X_{10}: the number of permanent teachers, X_{11}: quality management, X_{12}: school facilities, X_{13}: the number of assistants and administrative staff, X_{14}: cost per teacher or per person, X_{15}: students' features, X_{16}: transfer students, X_{17}: buildings and civil engineering structures, and X_{18}: plants and machinery.

Outputs: Y_1: the performance of students in specific courses, Y_2: the number of graduate students per school, Y_3: test performance on basic courses for accessing tertiary education, Y_4: the percentage of senior graduates, Y_5: the proportion of successful students to those who were enrolled at the beginning of the school year, Y_6: each school's average classification on national exams and the percentage of students with good scores, Y_7: the percentage of high school students who graduated and entered tertiary education, Y_8: the number of registered students, Y_9: selection of educational fields and Y_{10}: residence services.

The research papers from the empirical literature are presented in Table 1.

Table 1. Empirical studies that measure the efficiencies of secondary schools

	Authors	*Country*	*Years of reference*	*Sample of schools*	*Methodology*	*Inputs*	*Outputs*
1	Kirjavainen and Loikkanen (1998)	Finland	1997	291	DEA	X_2, X_3, X_4, X_5	Y_2,Y_3
2	Steve Bradley, Geraint Johnes, and Jim Millington (2001)	England	1993–98	All the schools	DEA	X_3, X_6, X_7	Y_1
3	Muñiz (2002)	Spain	1996–97	60	DEA	X_5, X_9, X_{14}	Y_5,Y_6
4	Mante and O'Brien (2001)	Australia	1998–99	250	DEA	X_1	Y_6
5	Ngee Kiong et al. (2004)	Malaysia	2002	16	DEA	X_{11}, X_{12}, X_{15}	Y_3
6	Primont and Domazlicky (2006)	Missouri USA	2001	120	DEA	X_{19}, X_{16}	Y_6
7	Waldo (2007)	Sweden	2000	287	DEA	X_1, X_6, X_7	Y_1
8	W. Robert J. Alexander, Alfred A. Haug, and Mohammad Jaforullah (2007)	New Zealand	2001–02	324	DEA	X_6, X_7, X_{10}, X_{13}	Y_6
10	Barnett et al. (2010)	United Kingdom	1994–96	152	DEA	X_6	Y_1
11	Lassibille and Tan (2010)	Tanzania	1994–96	150	DEA	X_2, X_3	Y_1
12	Masood Badri et al. (2011)	Abu Dhabi	2008–09	22	DEA	X_3, X_{14}	Y_6
13	Gronberga et al. (2012)	Texas, USA	2004–09	50	DEA, SFA	X_2, X_{10}	Y_1, Y_3
14	Essid et al. (2013)	Tunisia	2005–06	332	DEA	X_{10}, X_{12}, X_{13}	Y_6, Y_{10}
15	Rzadzinski L. and Sworowska A. (2016)	Poland	2009–11	27	DEA, SFA	X_6, X_{17}, X_{18}	Y_2, Y_8,
			Greece				
1	Maragos and Despotis (2003)	Greece	2001–02	60	DEA	X_1, X_{10}	Y_4,Y_7

Notes: DEA = Data Envelopment Analysis, SFA = Stochastic Frontier Analysis.

The empirical literature revealed that DEA was the most frequently used method for analyzing efficiency in the context of secondary education, although other methods such as SFA, though less popular, have also been used. In most research studies, two or three inputs with a respective one or two outputs were utilized. In such empirical studies, either the IO or the OO is used. The model could have an IO framework, which refers to the determination of minimum inputs for producing a given level of output or an OO framework by focusing on the maximization of outputs with given levels of inputs. Summarizing the results from past research, some main points can be highlighted: Schools generally presented satisfactory efficiency scores, even though there was evidence that a further improvement and advancement in certain areas is applicable.

The correlation between efficiency and student satisfactory achievements seemed to be positive. The number of students was not a critical indicator of school efficiency, unlike the cost indicator per teacher/student. The school type, either private or public, had a significant impact on school efficiency, whereas the impact of the school location, in urban vs. semi-urban/rural areas, was less important. The specific features of the students' families, such as the parents' socioeconomic level, probably played a vital role in the expected educational outcome (Kirjavainen and Loikkanen, 1998). In Greece, only one study (Maragos and Despotis, 2003) has been conducted with a small sample. It focused on 60 schools in Attiki municipalities. According to the researchers, during the second school year of their study, schools were more efficient, even though the input and output data were approximately identical. Some studies (Katharaki and Katharakis, 2010; Giannias and Sfakianaki, 2011; Tsamadias and Kyratzi, 2014; Kyratzi, Tsamadias and

Giokas, 2015) have been published regarding tertiary institutions.

3. Empirical Analysis

The empirical study of this research uses DEA with the input-oriented model (IO). Moreover, IO was selected because it was hypothesized, at least from a longer-term perspective, that outputs had fewer SSS choice variables than inputs for our SSS, so input choices were assumed to predominate (Millan and Chan, 2006).

3.1 Methodology

The DEA method has its origins in the work of Charnes et al. (1978), who reformulated Farrell's (1957) seminal work. The aim of DEA is to estimate the relative efficiency among homogeneous SSS/DMUs that have the same technology to pursue similar objectives (outputs) by using similar resources (inputs). DEA forms a line of optimal production (a frontier) with efficient DMUs and spreads all other (inefficient) DMUs below that line, commonly referred to as the *envelope*. The efficiency of individual DMUs is then calculated relative to that frontier/envelope (Tajnikar and Debevec, 2008).

Efficiency scores range from zero to one. DMUs on the frontier obtain efficiency scores equal to one, which means that they are efficient. It is worth mentioning that those DMUs indicated as efficient are only efficient in relation to other DMUs included in the examined sample. A DMU with an efficiency score of less than 1 is considered to be relatively inefficient. Consequently, DEA constitutes a good evaluation technique for the relative efficiency of a DMU, but it is not the most appropriate measure of absolute efficiency, as there is no comparison with what is regarded as maximal (Cooper et al., 2006). A technical problem is that there is some empirical evidence that suggests that the results of DEA are sensitive to assumptions made about the returns to scale in education production (Kirjavainen and Loikkanen, 1998).

As the DEA method is non-parametric, there are no statistical tests to assess such assumptions. In this study, DEA is applied under the Constant Returns to Scale (CRS) or Variable Returns to Scale (VRS) hypotheses. The CRS hypothesis assumes that there is no significant relationship between the scale of operation and efficiency. On the other hand, VRS's underlying assumption is that a rise in inputs is expected to result in a disproportionate rise in outputs (Joumady and Ris, 2005). In our analysis, we computed both CRS and VRS efficiency scores. The IO models are developed as follows (Cunha and Rocha, 2012):

Input-Oriented—CRS

$$\min_{\theta,\lambda} \theta$$

s.t.

$$\begin{aligned} Y\lambda &\geq Y_i \\ X\lambda &\leq \theta X_i \\ \lambda &\geq 0 \end{aligned} \tag{1}$$

and

Input-Oriented—VRS

$$\min_{\theta,\lambda} \theta$$

s.t.

$$\begin{aligned} Y\lambda &\geq Y_i \\ X\lambda &\leq \theta X_i \\ N1'\lambda &= 1 \\ \lambda &\geq 0 \end{aligned} \tag{2}$$

where λ is the vector of relative weights $(N \times 1)$ given to each DMU and N is the number of DMUs. Assuming that there is available data on I inputs and O outputs, X represents the matrix of inputs $(I \times N)$, and Y, the matrix of outputs $(O \times N)$. For the i-th DMU, the inputs are represented by the column vectors X_i, and the outputs by Y_i, respectively. This framework is consistent with the CRS model. The CRS assumption is avoided in the VRS model (Banker et al., 1984) by the introduction of an additional constraint on the λ, allowing returns to scale (i.e., $N1'\lambda = 1$, where $N1'$ is a vector of ones). This restriction imposes convexity on the frontier. Finally, the efficiency score (ϑ) is a scalar that estimates the technical efficiency (known as managerial efficiency) by assuming values between 0 and 1, with a value of 1 indicating a point on the frontier and, hence, a technically efficient school (Farell, 1957). The ratio of CRS/VRS was also interpreted as the Scale Efficiency (SE), which refers to the ability of each unit to operate at, its best scale of functions. In the present study, the DEA was accomplished with the Data Envelopment Analysis Program (DEAP), Version 2.1 software package (Coelli, 1996).

3.2 Variables' Sampling, Sources, and Data

To develop and estimate the models applicable to the present analysis, three input variables were used for each SSS: X1: the number of students, X2: the number of teachers, and X3: the public expenditures and two output variables, Y1: the number of students who achieved admission to higher educational institutions through national exams and Y2: the average score in the third-grade courses of SSS students.

The abovementioned variables were the most commonly used in the relevant research (see Table 1). For these variables, there is official data from the Ministry of Education, while no completed measurements exist for the rest.

The study used an SSS sample with stratified proportional sampling. To determine the minimum sample size, the following procedure was adopted; the minimum required sample size was estimated according to equation (1), and was based on the following parameters and assumptions (Lohr, 1999): From a pilot survey in 17 schools ($n^*=17$, 10% of the target population $N=165$), the standard deviations (s) of the most important variables (CRS and VRS) were estimated, and the greatest of these standard deviations ($s=0.02$ for VRS values) was entered in equation (1).

1. The confidence level was predetermined at 95%. Therefore, a value of $Z=1.96$ was utilized, based on the standard normal distribution function.
2. The acceptable margin of error (d) was predetermined at ± 10% of the range (0.99–0.95) of the VRS values recorded from the pilot sample. Therefore, the margin of error was set equal to $d=0.10\times0.04=0.004$.
3. The population of SSS in Central Macedonia was 165 (see Table 2).
4. From equation (1):
$$n=(1-\frac{n^*}{N})(\frac{Z\cdot s}{d})^2 \quad (1)$$
for $n^*=17$, $N=165$, $s=0.02$, $d=0.04$, and $Z=1.96$, it was found that $n\approx87$. The final minimum required sample was increased by 5% to reach the value $n=92$.
5. It was assumed that the minimum sample size needed for the simple random sampling scheme is an upper bound for the minimum required sample size for all other well-established designs based on random sampling.

Afterwards, the proportional stratified sampling was used where the school population was divided into two layers (strata), and then sub-samples were selected by simple random sampling from each stratum. One stratum was a) the city schools (urban), and the second was b) the suburban/rural schools, as shown in Table 2 below. A sample of proportionate stratified sampling in each layer was selected so the ratio of the sample size in the layer to the total sample size would be approximately equal to the proportion of the population size of the layer to the size of the total population. Thus, the total sample is a miniature proportional population (Psarrou and Zafiropoulos, 2001).

Table 2: Total number of Senior Secondary Schools (SSSs) in Central Macedonia by area and counties; also the stratified population and sample of SSSs in Central Macedonia

Counties of Central Macedonia	*Population*			*Sample*		
	Total number	*In urban areas*	*In semi-urban /rural areas*	*Sample number*	*In urban areas*	*In semi-urban /rural areas*
Imathia	12	5	7	7	3	4
Thessaloniki	92	58	34	51	33	18
Kilkis	10	2	8	6	1	5
Pella	11	2	9	6	1	5
Pieria	12	5	7	6	3	3
Serres	18	5	13	10	3	7
Chalkidiki	10	2	8	6	1	5
Total	**165**	**79**	**86**	**92**	**45**	**47**

Source: The population according to the Regional Education Department of Central Macedonia
Note: The sizes of the sample strata are from the author's calculations

The mechanism of school financing is the same all over the country and comes from the Ministry of Education for the payroll of teachers and from the municipalities for schools' functional expenses. The total amount of financing by the municipalities depends mainly on the number of students and much less from each school's area. This study's data collection has been accomplished with the help of the information systems and the databases that every school maintains.

3.3 Statistical Analysis

To summarize the available data minimum (min) and maximum (max) values, the means and standard deviations (SD) were calculated for the technical efficiency (TE) by using the CRS and VRS hypotheses/specifications and scale efficiency (SE) indicators. The ANOVA method was employed to investigate the effect of the school year and the region on the CRS, VRS, and SE values. ANOVA was performed according to the general linear model that involves one factor between the school units (factor "the two-level region": urban and semi-urban/rural) and one factor within the school units (factor "2007–08 and 2010–11 school years") with repeated measures (Girden, 1992; Kirk, 1995). Furthermore, the Least Significant Difference (LSD) criterion was used to compare the mean values (Toothaker, 1993). In all the statistical tests conducted, the significance level was pre-set at $\alpha=0.05$. The SPSS v15.0 statistical software was used for all the statistical analyses.

4. Results and Discussion

Table 3 below presents summary statistics of input and output variables for SSSs.

Table 3. Descriptive statistics of input and output variables for SSSs

Variables	*Inputs*[1]			*Outputs*[2]	
Statistics	X_1	X_2	X_3	Y_1	Y_2
School year 2007–08					
Mean	219.4	25.7	735015.8	60.1	14.4
SD	21.0	5.0	42082.3	16.0	0.8
Max	544.0	62.0	1577674.5	144.0	16.6
Min	30.0	7.0	192618.0	6.0	12.8

School year 2010–11					
Mean	233.5	28.2	750039.4	58.8	14.3
SD	16.0	1.0	73904.5	12.0	0.6
Max	513.0	58.0	1760500.4	146.0	16.5
Min	44.0	8.0	183867.4	5.0	12.8

Source: Authors' calculation

[1]X_1: number of students, X_2: number of teachers, X_3: public expenditures
[2]Y_1: number of students who achieved admission to higher educational institutions through national exams, Y_2: average score in third-grade courses of SSS students.

In Table 3, for both years, we can see that there are some schools with a very small student population and others with a very big one (X_1). The students who attend large schools tend to have better average scores (Y_2) in the third-year courses than the students at small schools. It is noteworthy that in the school year 2007–08 the average size of SSS was 219.4 students, whereas in the 2010–11 school year, it was 233.5. Data from official records showed that, for the year 2008, the student–teacher ratio for senior secondary education in Central Macedonia was 1:8.5. In Greece, it was 1:7.9; in the EU, it was 1:11.4. Last, in the OECD it was 1:12.5 (OECD, 2009b). For the year 2011 in Central Macedonia, the student–teacher ratio was 1:8.3. In Greece, it was 1:8.2, and in the EU, it was 1:12.7. In the OECD, it was 1:13.9 (OECD, 2013). When the model-oriented technique is used to reduce input weight on the volume outflow (IO), the results obtained are shown in Table 4.

For CRS, ANOVA showed that the main effect of the school years was statistically significant (P<0.001). On the contrary, the main effect of the region was not (P=0.331). The interaction "school year × region" was also not statistically significant (P=0.145). Table 4 shows that, in urban areas, there was a statistically significant difference between the two school years (P<0.001), something that is also valid in the case of the rural areas (P=0.001). The effect of the second school year (2010–11) was statistically higher than that of the first year (2007–2008). The same findings also apply to the entire sample. For VRS, ANOVA showed that neither the effect of the school years (P=0.254) nor that of the region (P=0.686) was statistically significant. The interaction "school year × region" was also not statistically significant (P=0.748). For SE, ANOVA revealed that the effect of the school year was statistically significant (P<0.001). The same result was valid in the case of the regional effect (P<0.001) as well as regarding the interaction "school year × region" (P<0.001). Table 4 shows that in urban and semi-urban/rural areas there was current evidence to support considerable difference between the two school years (P<0.001 in both comparisons). However, in school year 2010–11 there were no statistically significant differences between urban and semi-urban/rural schools (P=0.977).

Table 4. Technical and scale efficiency of the total SSS sample for the stratified sample of SSSs in urban and semi-urban/rural areas in Central Macedonia for the school years 2007–08 and 2010–11

D.m.u		*School year 2007–08*			*School year 2010–11*		
		Technical		*Scale*	*Technical*		*Scale*
		crs	*vrs*	*se*	*crs*	*vrs*	*se*
UA	Mean	0.707b*	0.823a*	0.864b*	0.828a*	0.836a*	0.991a*
	Max	1	1	1	1	1	1
	Min	0.548	0.601	0.673	0.511	0.516	0.939
SUA	Mean	0.750b*	0.809a*	0.928b*	0.825a*	0.832a*	0.991a*
	Max	1	1	1	1	1	1
	Min	0.510	0.521	0.792	0.580	0.583	0.964
Total schools	Mean	0.729b*	0.815a*	0.897b*	0.827a*	0.834a*	0.991a*
	Max	1	1	1	1	1	1
	Min	0.510	0.521	0.673	0.511	0.516	0.939

Source: Author's calculation

Notes: SSS: Senior Secondary School, UA: schools in urban areas, SUA: schools in semi-urban/rural areas, CRS: Constant Returns to Scale, VRS: Variable Returns to Scale, SE: Scale Efficiency, *: for the total sample of SSSs and within each area (UA and SUA), mean values of the same index (crs, vrs, and se) followed by different letters are statistically significantly different, at α=0.05, according to the LSD criterion.

From Table 4, it is evident that, on average, with regard to technical efficiency (TE) via the CRS hypothesis, we can count on a decreased 27.1% need for inputs for 2007–08 by keeping the same outputs, while for 2010–11, we can rely on a decreased 17.3% need, respectively. For the TE via VRS hypothesis, we can count on a decreased 18.5% need for inputs for 2007–08 by keeping the same outputs, while for 2010–11, we can rely on a decreased 16.6% need for inputs.

The scale efficiency (SE) is equal to CRS/VRS and refers to the ability of each unit to function at the maximal operating range. Deconstructing the efficiency scores from the CRS DEA into scale (in)efficiency and "pure" technical efficiency shows that, on average, for the school year 2010–11, schools operated close to the optimal scale 1 (0.991). This result shows that schools functioned 0.009 (0.9%) from the optimal scale. SE is very high (>0.9), which would imply that schools have a good operations output regarding their own dimension. However, as far as the school year 2007–08 was concerned, the result showed that schools operated 0.103 (10.3%) from the optimal scale. Schools needed more input reduction in the school year 2010–11.

Table 4 demonstrated that, for the schools in our sample included in urban areas, the CRS could produce the same outputs using a 29.3% decreased pool of resources for 2007–08; for the school year 2010–11, the percentage was 17.2%. The VRS can produce the same outputs decreased by 17.7% and 16.4% for 2007–08 and 2010–11, respectively. We observed that, with regard to the SE, which is maximal at 1, the schools located in the urban centers of Central Macedonia, on average, were 0.136 (13.6%) from the optimal scale for the school year 2007–08 and only 0.009 (0.9%) respectively for the 2010–11 school year. The average efficiency of schools was very close to the maximum in the 2010–11 school year during the economic crisis.

As far as the schools in semi-urban/rural areas are concerned, we had the following results. For TE via the CRS hypothesis, we can produce the same outputs by utilizing a set of resources decreased by 25% for 2007–08 and by 17.5% for 2010–11. With regard to TE via the VRS hypothesis, we can achieve the same outputs while decreasing the inputs by 19.1% for 2007–08 and by 16.8% for 2010–11.

We have noticed that, for the SE, the schools located in the semi-urban/rural areas of Central Macedonia, on average, were 0.072 (7.2%) from the optimal scale for the school year 2007–08 and only 0.009 (0.9%), respectively, for the 2010–11 school year. The results of the present research on the IO model show that the average technical efficiency during the school year 2010–11 was better than the respective one during the school year 2007–08. Within the same year, the technical efficiency of the semi-urban/rural SSS was slightly lower than the one of urban centers. The results regarding the location of schools during 2010–11 are similar to previous studies (Mante and O'Brien, 2001; Ngee Kiong et al., 2004; Masood Badri et al., 2011; Gronberga et al., 2012).

We see that schools were not terribly efficient in 2007–08, while in 2010–11, during the crisis, they functioned more efficiently. This is due to schools' better management of resources, not the likely threat of professors' redundancy or any other extreme measurements that the Greek government took.

5. Conclusion

Secondary education plays a key role in each country or region in this age of the knowledge society. The resources received from the government must be used more efficiently to meet the increasing demand for education. Hence, an educational authority should investigate not only the educational outputs produced by the school, but also the resources utilized in producing the outputs. This paper applied the DEA (input-oriented) methodology to evaluate the relative efficiency of senior secondary schools in the Central Macedonian region in Greece. It used three inputs and two outputs. The efficiency (technical or scale) scores indicate which schools need improvement, which can be achieved by decreasing the inputs.

The results revealed that:

First, the majority of the studied schools were found to be inefficient.

Second, in the school year 2010–11 (during the economic crisis in Greece), the technical and scale efficiencies of senior secondary schools were on average higher than those of the 2007–08 school year (before the crisis).

Third, in the school year 2007–08, the scale efficiency (SE) of schools in urban areas was lower than the examined efficiency of schools in semi-urban/rural areas.

Fourth, in the school year 2010–11, the scale efficiency (SE) for the total sample of schools was the same for the schools in urban and semi-urban/rural areas.

Our findings are expected not only to offer useful insights for policymakers to enable them to consider possible solutions for improving the performance of senior secondary schools, but also to provide a significant benchmark for the following comparative studies on the performance of secondary education in Greece. We propose that policymakers establish an observation post on the periphery and throughout the country to observe the performance of SSSs annually and whenever they find it necessary to intervene to make improvements. Moreover, the suitable reallocation of resources would increase the efficiency scores of inefficient schools.

The observatory will be a collaborative effort between European and international education institutions. It will advance the development of innovative mechanisms for the distribution of resources which are very little during an economic crisis, according to school records.

Further research can extend this study. For instance, future studies could introduce additional input and output variables. Moreover, researchers might use a combination of available techniques such as bootstrapping to estimate the efficiency of schools over a longer period of time and after the economic crisis.

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