Longitudinal Evaluation of Greek Regional Policies Using Window Data Envelopment Analysis

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Abstract
The main objective of the regional policy is to diminish the gap and reduce the disparities among regions. According to that, regions try to benefit from a range of socioeconomic factors in order to achieve a standard rate of economic growth. The endeavor of Greek regions to improve their competitiveness is supported by central government's actions which are incorporated in a general political framework for regional development. The aim of this article is to evaluate the effectiveness of the way that each Greek region utilizes its resources in order to achieve the target of the economic growth. Data Envelopment Analysis (DEA) is adopted in order to evaluate the efficiency of Greek regions. Additionally a DEA model for panel Data DEA Window Analysis will be implemented in order to extract more accurate results of the efficiency of Greek regions. The paper will focus on the period 2000-2007.

Keywords: Longitudinal Analysis, DEA Window Analysis, Regional Development, Greek Regional Policies

JEL classification: C14, R11, R15, R58

Introduction

The main objective of regional policy is to diminish the gap and reduce the disparities among regions and both public and private investments constitute its basic tools. The implementation of an effective pattern of the distribution of these investments is a crucial issue, directly affecting the competitiveness of a national economy. Specifically, the effective distribution of investments to the regions of a country can support the least advanced regions to attain a high rate of economic growth. Investments are associated with possibilities, such as the growth of employment, the strengthening of local population and the increase of regions' competitiveness. However, the efficiency of the regional policies, which have been implemented by many countries until today, still remains a subject under heavy consideration (Athanassopoulos, 1995; Polyzos and Petrakos, 2001).

Regional development constitutes a crucial issue for the Greek economy, as well. Several policies and relative actions have been implemented by the central government in order to reduce the disparities among regions. Investments seem to have an important role for the efficiency of Greek regional policies. Concerning the program of public investments (PPI), the main objective has been the economic strengthening of the weakest regions. Additionally, private investments can be forwarded to the less developed areas through several Development Laws. These Laws enforce the development of the weakest regions through tax and financial incentives for private investments (Halkos and Tzeremes, 2009; Polyzos et al. 2011).

Nevertheless, it is doubtful that the implemented policies fulfill the initial expectations of Greek policy planners due to the fact that the economic growth among Greek regions is still characterized as unequal (Polyzos et al. 2011). Taking this uncertainty into account, the present paper seeks to evaluate the efficiency of each region according to the way that it exploits the possibilities of regional policies in order to achieve a high level of economic growth. The paper will rely on the methodology of Data Envelopment Analysis in order to benchmark the efficiency of Greek regions. Moreover, a modification of DEA for panel data (DEA Window Analysis) will be adapted in order to exploit more accurate results and capture time trends in the efficiency of the regions.

The structure of the paper is organized as follows. Section 2 provides a brief presentation of DEA and presents all the previous attempts incorporating DEA in the evaluation of regional policies efficiency. A more detailed bibliographical review is provided for the use of DEA in the evaluation of Greek regional policies. Section 3 provides the methodology that is adapted by the present paper and analyzes the variables that will be used in the model, in order to capture the efficiency of Greek regions. The empirical results are presented in Section 4, as well as a discussion about the ability of each region in achieving a standard level of economic growth. Finally, in Section 5 the main findings of the study are highlighted.

DEA methodology and its use for the evaluation of regional efficiency

DEA constitutes a data analysis method aiming at the comparison of technical efficiency of the so called Decision Making Units (DMU). It involves the solution of a series of linear programming problems, in which both the inputs and outputs of the production process are employed to calculate the relative efficiency of each DMU. The methodology was first suggested by Farrell (1957) and it was then extended by Charnes et al. (1978) and Banker et al. (1984). The two basic DEA models refer to the DEA-CCR model which assumes constant returns to scale (CRS), and the DEA-BCC model which assumes variable returns to scale (VRS) (Niavis and Polyzos, 2011).

DEA displays strong advantages but also several weaknesses. DEA constitutes a strong managerial tool because the results of the DEA models can be used in order to benchmark organizations, identify the best practices and direct several policies and actions. Furthermore, an important advantage of DEA is its simplicity, as it constitutes a non-parametric analysis, which is independent from assumptions on production functional form and error distribution. On the other hand, this simplicity comes with the cost of generating results which lack statistical properties. Additionally, another drawback of the method derives from the fact that this method constitutes a comparative evaluation of DMUs so, in many cases DMUs are rendered as relatively efficient, while in absolute terms they do not operate efficiently (Niavis and Polyzos, 2011; Polyzos, 2011).

DEA has been used sufficiently in the international bibliography for the estimation of spatial units' efficiency (MacMillan, 1986; Charnes et al., 1989; Hashimoto and Ishikawa, 1993; Chang, Hwang and Cheng, 1995; Athanassopoulos, 1996; Byrnes and Stobeck, 2000; Martic and Savic, 2001; Demchuk and Zelenyuk, 2009). Concerning the case of Greek regions, the methodology has firstly been applied by Athanassopoulos (1995), who used a combination of mathematic programming and DEA, in order to assess an efficient pattern of distribution of central resources to the local authorities. Moreover, Karkazis and Thanassoulis (1998) used the DEA in order to evaluate the efficiency of regional policies that have been applied in North Greece. Additionally, Halkos and Tzeremes (2009) adapted DEA in their paper in order to evaluate the efficiency of Greek regions for the period 2003-2006. Finally, Polyzos et al. (2011) used DEA in order to rank the Greek prefectures according to their efficiency scores and to identify potential sources of prefectures' inefficiency.

The present paper, as it was mentioned before, will rely on DEA method with a dynamic model which can include panel data. In this section the formulation of the DEA model that will be implemented for the Greek regions' efficiency analysis is presented. In order to create a DEA problem several a-priori assumptions should be made. Let us assume that there are n regions to be analyzed, each of which uses m inputs to produce s outputs. Assume that $x_{ij} > 0$ is the amount of input i used by the region j and $y_{rj} > 0$ is the amount of output r produced by that region. In this study, it is assumed that the objective is to maximize the output produced by regions using a standard level of inputs; hence, an output-oriented model is considered as more suitable than an input-oriented model. The output-oriented DEA-CCR model can be described as:

$$\begin{aligned} &\max \varphi \\ &\text{s.t.} \ \sum_{j=1}^{n} x_{ij}\lambda_j \le x_{io} \quad i = 1,2,\dots,m \\ &\sum_{j=1}^{n} y_{rj}\lambda_j \ge \varphi y_{ro} \quad r = 1,2,\dots,s \\ &\lambda_j \ge 0 \quad j \ne o \end{aligned} \tag{1}$$

Where,

y_{ro} , x_{io}	The rth output and ith input for a region o under evaluation.
λ_j ,	The decision variables which represent the weights region j would place on region o in constructing its efficient reference set.
φ^* ,	The decision variable which represents the relative technical efficiency of region o.

The variable φ^* can receive either the unit value, which renders one unit relatively efficient or a value higher than unity (> 1), which renders one unit relatively inefficient. The DEA-BCC model results from adding the convexity condition $\sum_{j=1}^{n} \lambda_j = 1$ to the constraints of the DEA-CCR model (1).

Additionally to the two basic DEA models, DEA Window Analysis is implemented in order to capture the efficiency trends of Greek regions. For the execution of a DEA Windows Analysis problem the basic DEA models should be calculated. Furthermore, the certain model considers a region under evaluation as it was a different region over time. Thus, a number of windows are constructed and the DEA models are adjusted to the data of each window. In order to construct a DEA Window Analysis problem several assumptions should be made about the number and the size of windows. Moreover, the procedure requires the fragmentation of the period analysis T into sub periods or windows. Each window (w) has the same length (p) with the others. Supposing that the problem focuses on the evaluation of efficiency of N regions, then the first window contains N_w regions under evaluation for the sub period $(1,....,p)$. The second window includes N_w regions under evaluation for the sub period $(2,...,p+1)$. The procedure is repeated until the efficiency of the regions that are included in the last window of the sub period $(\mathrm{T}-\mathrm{p}+1,....,\mathrm{T})$, is estimated. The number of the regions that are finally evaluated in each window is given by $N_w = N*\mathrm{p}$ and the total number of regions under evaluation is equal to $N_{tw} = N*\mathrm{p}*\mathrm{w}$ (Cooper et al. 2000).

Evaluating Greek regional efficiency

The analysis will focus on the efficiency of Greek regions for the period 2000-2007. The "inputs" of the model are the per capita public[1] (*Pub*) and private investments (*Priv*) of each region for the particular period, as well as the building activity that was developed in each region expressed in per capita km^2 of new residences (*Res*). Moreover, the per capita GDP of each region for the period 2000-2007 will be used as the "output" of the present model (*GDP*). The choice of this particular time period is based on the fact that it coincides with the period of application of Investment Law 2601/98 and the first phase of Investment Law 3299/04.

These variables express sufficiently the economic activity of each region, while they incorporate the effect of regional policies expressed via the investments of Program of Public Investments and the two Development Laws. Additionally, inputs also include an indicator of pure private initiative via the activity of building sector. On the other hand, the variable of GDP per capita denotes sufficiently the production output of each prefecture, constituting an important economic indicator and a sufficient standard of living, as well.

[1] Public investments concern expenses of the Program of Public Investments (PPI)

The present paper will rely on the VRS-DEA since the contribution of each investment in the increase of the GDP per capita is not equal. So, the VRS-DEA model is more suitable in evaluating the efficiency of regional economies from the CRS-DEA model (Halkos and Tzeremes, 2009). The structure of the windows for the first region under evaluation is presented in Table 1. The prices of the variables that are used in order to construct the windows of the problem are presented in the last row of Table 1. The adoption of DEA Windows Analysis has significant advantages because its results provide more detailed information about the performance of each region than the information gathered from the basic DEA models. Furthermore, as can be seen from the Table 1 the columns of the scores can be used in order to test the stability of each region's efficiency and the scores of the rows can be used in order to capture the efficiency time trends. However, it should be noted that the major drawback of the method is that there is an inconsistency in the number of times that each period is tested. In the present model the regions of first and last period are tested only once, while the regions in periods 3 and 4 are tested four times (Cooper et al. 2000).

Table 1: The structure of DEA Window for the first region under evaluation

	2000	2001	2002	2003	2004	2005	2006	2007
Region 1								
T=8,N=13,p=4,w= 5								

The formulation of the DEA Window Analysis problem for the first window of the Greek regions case is described as follows:

$$\max \ \varphi$$
$$s.t.$$
$$\sum_{j=1}^{N_1} Priv_j \lambda_j \leq Priv_o$$
$$\sum_{j=1}^{N_1} Pub\lambda_j \leq Pub_o$$
$$\sum_{j=1}^{N_1} Res_j \lambda_j \leq Res_o \tag{2}$$
$$\sum_{j=1}^{N_1} GDP_j \lambda_j \geq \varphi GDP_o$$
$$\sum_{j=1}^{N_1} \lambda_j = 1, \ \lambda_j \geq 0 \ \forall j, \ N_1 = (1,2,....,52)$$

Results

The descriptive statistics of the variables of the model for the period 2000-2007 for each region are presented in Table 2. The mean values of the variable Priv leads to the conclusion that more than half of the regions attracted private investments whose value is lower than the average. The region with the highest value of the per capita private investments during the period 2000-2007 is Crete. Additionally, only five of the regions attracted public investments whose value exceeds the Greek average. The region which attracted the highest part of the Greek PPI is West Macedonia. Moreover, the results of the building sector denote that six of the Greek regions managed to exceed the Greek average of per capita building activity. The highest building activity is observed in Ionian Islands. Finally, only four regions have a per capita GDP which exceeds Greek average per capita GDP. The region with the highest pp GDP is Attiki.

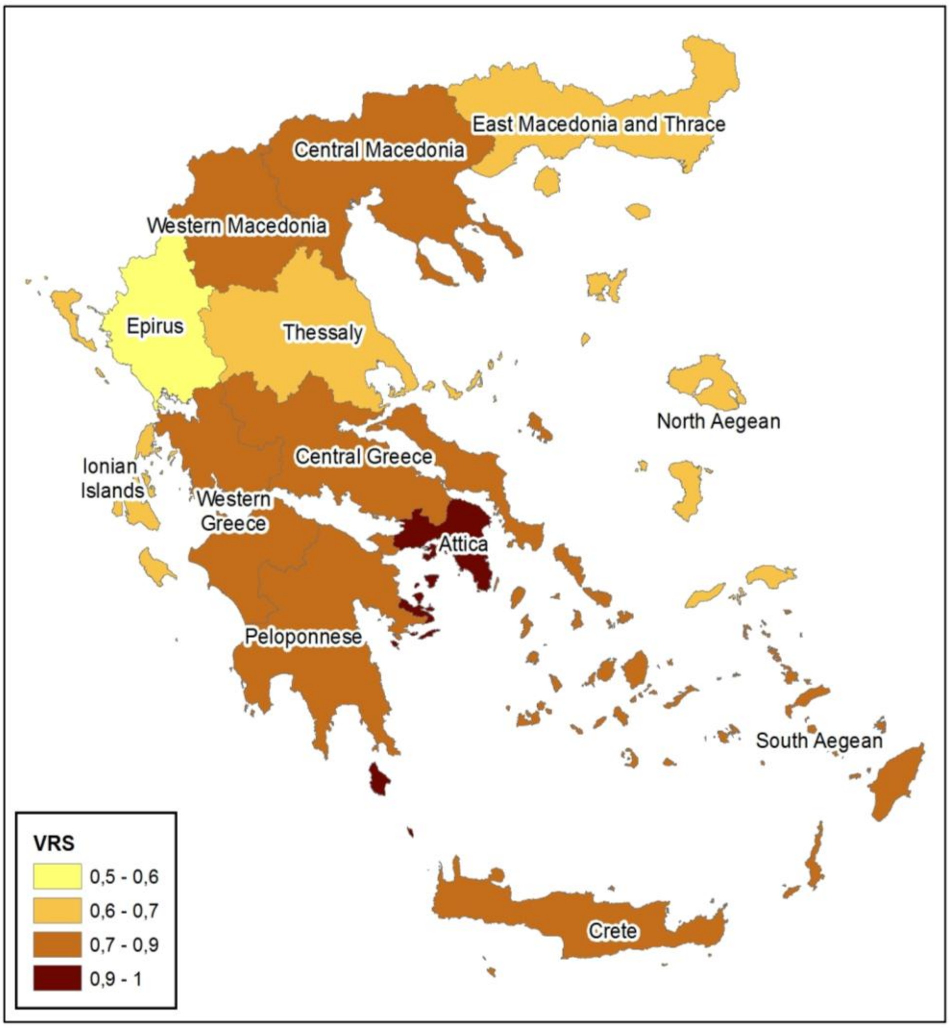
Table 2: Descriptive statistics of the model variables

Region	*Priv*	*Pub*	*Res*	*GDP*
East Macedonia -Thrace	124,72	448,99	0,0013	11119,98
Central Macedonia	51,41	342,40	0,0014	13123,60
West Macedonia	51,15	724,81	0,0013	13245,03
Ipeiros	115,85	552,28	0,0015	12312,89
Thessaly	57,03	397,40	0,0013	12297,42
Ionian Islands	106,79	475,35	0,0020	13661,16
West Greece	51,51	413,03	0,0012	10779,02
Central Greece	91,63	525,67	0,0016	15760,25
Attiki	9,31	552,59	0,0012	21711,53
Peloponnisos	41,50	380,70	0,0017	13283,02
North Aegean	59,23	594,96	0,0013	11659,61
South Aegean	152,18	480,42	0,0021	17368,66

Crete	158,21	462,59	0,0016	14763,11
Mean	82,35	488,55	0,0015	13929,64
St. Dev.	45,91	102,54	0,0003	2976,17

The results of the application of DEA Window Analysis to the Greek Regions are presented in Map 1. The gradation of the mean efficiency values which is presented in Map 1 leads to the conclusion that there are important differences among the efficiency levels of Greek regions. As can be seen from Map 1 there is not any region with mean efficiency below 0,5. However inefficiency in the Greek regional system is present. Moreover, Attiki region is the most efficient region in Greece, as Attiki retains the highest mean efficiency value during the whole period (0,97). Seven regions are found to have an efficiency score which ranges between 0,7-0,9. This category of regions operates at an acceptable level of efficiency. Nevertheless, improvements on the utilization of their economic sources are necessary. The next category includes the regions with efficiency scores which range between 0,6-0,7. These regions are North Aegean, Thessaly, Ionian Islands and East Macedonia-Thrace. The GDP per capita of the regions of this category is lower than the Greek regions' mean GDP per capita level. The efficiency status and the relatively low GDP per capita of these regions show that the regional policies of the period 2000-2007 failed to diminish the gap of growth rates among Greek regions. Finally, Ipeiros is found to be the most inefficient region with an efficiency score which don't exceed the price 0,6. The Greek regional policies failed to ensure a sufficient level of economic growth for the region. Undoubtedly, Ipeiros remains the most problematic region according to the welfare level that provides to its residents.

Map 1: Mean efficiency scores of Greek regions (2000-2007)



Attiki seems to be the most efficient region regarding the utilization of investments and it has achieved high levels of economic growth. The high efficiency of Attiki and its rapid development in the period of analysis emanates from the favourable conditions of growth that prevail in this region compared to the other regions, such as the existence of effective infrastructures, the development of economies of scope, economies of scale and agglomeration economies. Furthermore, Attiki was favoured from the organisation of the Olympic Games of 2004 because several investments were driven to the capital in order to meet the Olympic Games standards. Central Macedonia is also found to operate efficiently in the same period. The efficiency level of the region stems from the fact that it includes the second bigger city of Greece, Thessaloniki. As in the case of Attiki, several factors such as economies of scale and agglomeration economies, favour the economic development of the city and consequently of the region. On the other hand, Ipeiros is the least efficient region, taking into account the mean value of efficiency scores during the whole period. The region seems not to perform well because of negative effects of the region's isolation and low proximity.

A more detailed picture about the differentiation of regions efficiency levels during the period 2000-2007 can be extracted from the results that are presented in Table 3. Eight of thirteen regions are found to exceed the mean efficiency levels of Greece. Additionally, the range of efficiency scores during the period of analysis can be characterized as relatively high, since the mean value of total range of regions efficincy is 0,45. A remarkable result that confirms the high range of efficinecy scores is the fact that only two regions (Ipeiros and Ionian Islands) did not reach even for one period the value of full efficiency (1). The highest range of efficiency score is found for region West Greece and the lowest range for the region Attiki. Additionally, the column range of scores which constitutes a metre of stability of efficiency measures, denotes that as the data changes to the sequence of evaluation windows, the efficiency scores are becoming sensitive but in different level for each region. The highest range of efficiency scores for Greek regions is observed in the calculations of years 2003 and 2004. Only the efficiency scores of Attiki present the highest column range in the analysis of year 2002.

Table 3: DEA Window Analysis detail results

Regions	*Efficiency*	*St. Dev.*	*Column Range*		*Total Range*	*Min*	*Max*
			Year	**Range**			
East Macedonia - Thrace	0,61	0,16	2003	0,31	0,59	0,41	1,00
Central Macedonia	0,84	0,20	2004	0,52	0,52	0,48	1,00
West Macedonia	0,74	0,19	2004	0,52	0,52	0,48	1,00
Ipeiros	0,56	0,07	2003	0,22	0,24	0,46	0,69
Thessaly	0,66	0,16	2004	0,3	0,54	0,46	1,00
Ionian Islands	0,64	0,10	2003	0,28	0,33	0,48	0,81
West Greece	0,75	0,24	2004	0,61	0,61	0,39	1,00
Central Greece	0,81	0,15	2004	0,44	0,44	0,56	1,00
Attiki	0,97	0,04	2002	0,15	0,16	0,84	1,00
Peloponnisos	0,79	0,20	2004	0,53	0,53	0,47	1,00
North Aegean	0,66	0,19	2003	0,25	0,58	0,42	1,00
South Aegean	0,81	0,13	2003	0,29	0,38	0,62	1,00
Crete	0,72	0,14	2003	0,23	0,46	0,54	1,00
Mean Efficiency : 0,73 - Mean Total Range: 0,45							

The high column range of years 2003-2004 is reasonable because, as it was noted before, the central years of the period analysis are examined in a more detailed way. Additionally, these two years coincide with the expiration of Development Law 2601/98 and the implementetion of the new respective Law 3299/04. The changes that came up with the implementation of the new Law are captured from the DEA Window Analysis model, as the evaluation of every year’s efficiency is based on sequential analysis which can spot efficiency trends for periods, including years before and after the period of interest. The efficiency scores of Table 4 can be used in order to answer the question if Greek regions improved their efficiency status in the period which coicides with the application of the new Development Law. The results presented in Table 4 point out the differentiation in efficiency levels of Greek regions between the two periods according to to the efficiency scores that each region attains.

As it can be seen from the results presented in Table 4 the mean value of efficiency scores is found to be lower in the second period of analysis. The mean value of efficiency scores in the period 2000-2004 is 0,784 and the mean efficiency score for the period 2005-2007 is 0,620. Additionally, the majority of regions operated better in the period before the implementation of the second Law. Only two regions (Attiki and West Macedonia) managed to operate more efficiently in the second period of analysis. It should be noted that Attiki in the second period of analysis operates on the highest efficiency level, attaining an efficiency score which equals to unit. This is reasonable because the region started to utilize the benefits of the modern infrastructures that were built in Athens for the Olympic Games.

Table 4: Greek regions efficiency change between two periods

Region	*2000-2004*	*2005-2007*
	Efficiency	**Efficiency**
Attiki	0,958	1,000
Central Macedonia	0,946	0,580
Peloponnisos	0,884	0,572
Central Greece	0,874	0,662
South Aegean	0,848	0,723
West Greece	0,836	0,553
Crete	0,756	0,628
West Macedonia	0,737	0,738
North Aegean	0,720	0,510
Thessaly	0,720	0,524
Ionian Islands	0,672	0,570
East Macedonia -Thrace	0,663	0,474
Ipeiros	0,577	0,528
Mean	**0,784**	**0,620**

The range of efficiency scores between the two periods differs for each region, leading to a differentiation in the relative position of each of them. The relative position is based on regions' efficiency scores. The relative position of each region is presented in Figure 1. As it can be seen from the figure the relative position of six regions worsens in the second period. The biggest change is observed on the relative position of regions Central Macedonia and Peloponnisos, which were found to be among the more efficient regions in the first period of analysis. On the other hand, five of the regions improved their relative position in the second period. A remarkable change is observed for the region West Macedonia which is found to be the second more efficient region in the period after year 2004. Additionally, Ipeiros which was the most inefficient region of the first period retained its efficiency level and improved its relative position. The most inefficient region for the second period is found to be East Macedonia and Thrace. Finally, two of the regions (Attiki and Central Greece) kept their relative positions even though Central Greece did not improve its efficiency levels.

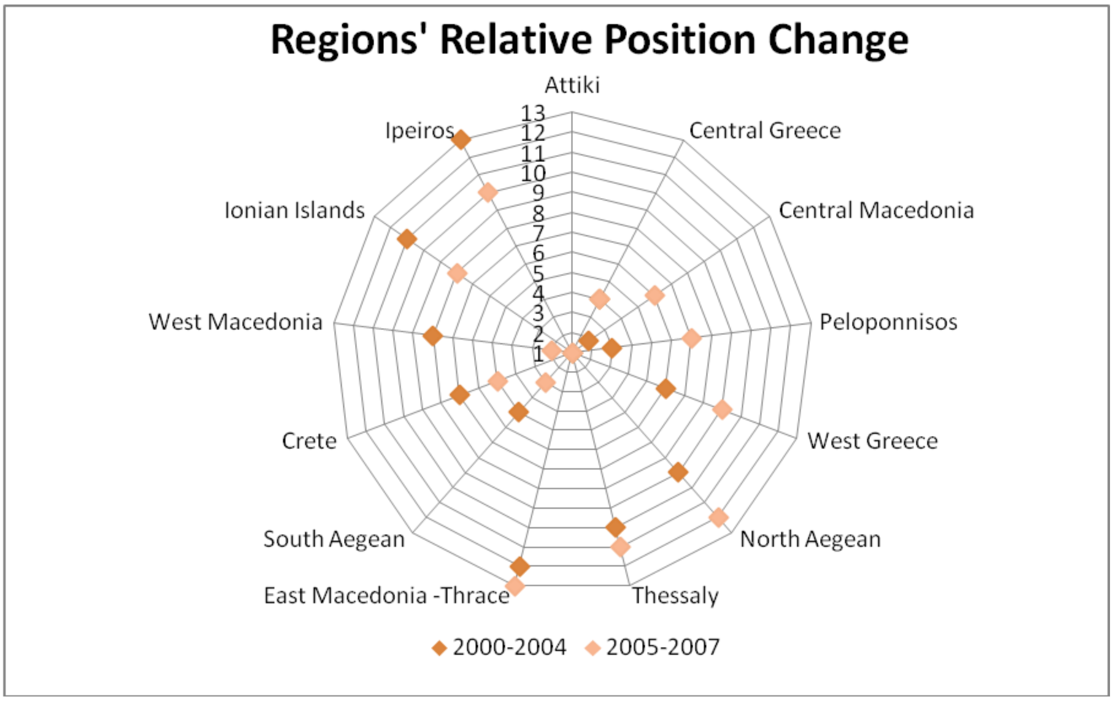


Figure 1: Greek regions' relative position change between the two periods

Conclusions

The main effort in the present paper was the efficiency evaluation of Greek regional system during the period 2000-2007. Analysis targeted mainly at the evaluation of effectiveness of public and private investments, as the main tools of applied regional policies. DEA Window Analysis was employed in order to get more detailed results than these obtained from the basic DEA models.

The results pointed out that the most efficient region during the period 2000-2007 was Attiki, followed by Central Macedonia. These results confirm the lack of an efficient regional policy in Greece. More precisely, the distribution pattern of public and private investments seems to favor the regions with large urban centers and high economic activity. Therefore, regional convergence is not achieved, since the less developed regions still lack of efficient utilization of its economic resources. The first phase of implementation of the Law 3299/04 brought up remarkable changes on the efficiency levels of Greek regions. These changes are also a result of the capability of each region to utilize efficiently the actions and motivation of the previous Law. The relative position of many regions which is based on their efficiency scores, changed. This fact verifies that the implemented of period 2000-2007 managed to re-allocate the resources across Greek regions. Nevertheless, the majority of regions in absolute terms are found to act more inefficiently than the way that they operated in the beginning of period analysis. Additionally, Development Laws seem to further favor Attiki since this region is judged as fully efficient in the period 2005-2007. Therefore, it could be said that the two Laws contributed to major changes to the distribution of investments but there is doubt if these changes have resulted in more efficient regional policy.

The effective utilization of investments should be the main target of regional policies. Several actions should be undertaken so that the less developed regions can fully utilize regional policies. The new Development Law (3908/11) which has been in effect since 2011 is expected to compensate for the inconsistencies of the previous laws. Moreover, actions such as the decentralization of administration, the strengthening of local authorities and the obliteration of bureaucracy can result in reducing the gap of regional development. In the period of crisis in which Greece has entered since 2010 the competitiveness of national economy has been rendered as the main issue. Furthermore, economic crisis restricts the funds that are directed towards the utilization of regional policies. Taking this under consideration regional policies should be more efficient than ever in order for Greece to attain a high level of economic growth.

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