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Regional Economic Convergence in Greece: A Stochastic Dominance Approach

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Abstract. Traditionally, the analysis of regional economic convergence is based on the notions of β -convergence and σ -convergence. However, both of these approaches have several drawbacks and limitations. To overcome these difficulties, we apply a more recent, non-parametric approach, which differs from the other non parametric kernel estimator approaches. This is the stochastic dominance approach, which is originally implemented in investment decision making. As an analytical tool for convergence analysis, stochastic dominance has many advantages, as it is based on minimal assumptions and it is not bound to a certain distribution. Additionally, it produces more evidence about the shape and the evolution of the regional per capita income distribution, rather than a simple measure of dispersion as the σ -convergence approach does. Thus, stochastic dominance analysis offers the possibility to examine the whole distribution of per capita income and also to test for polarization. In this study, we investigate the existence and the nature of the per capita income convergence between the Greek NUTS-III regions. Specifically, our data covers the 2000-2007 period and the 51 Greek prefectures. Moreover, convergence is studied using the traditional parametric approach of panel unit root test and σ -convergence, and the results are presented along with those of the stochastic dominance approach. In all cases, the results clearly suggest economic convergence for the whole period under investigation.

Keywords: stochastic dominance, regional convergence, Greece, GDP per capita

1. Introduction

In the last decades, economic convergence has been one of the major topics of interest in the economic literature. A vast volume of empirical research has been dedicated in the investigation of economic convergence, with not always similar results neither in qualitative nor in quantitative sense. Frequently, contradictory conclusions have been drawn and several reasons for this have been presented.

At the policy level, regional convergence is a major objective for all governments, while in the EU it has been an objective since the setting of the Treaty of Rome, in 1957. For this purpose, policies aimed at regional cohesion were strengthened through the European Regional Development Fund, the European Cohesion Fund and the European Social Fund (Michelis et al., 2004). Although the main purpose of these policies is the cohesion between EU countries, they may have a crucial impact on the cohesion within EU countries. Several studies examined the regional inequalities in European countries and according to Petrakos and Psycharis (2004), most of them conclude that the regional inequalities in Greece are limited relevant to those of the rest of the EU countries. However, according to Monastiriotis (2008), the nature of disparities and the regional backwardness in Greece, appears to be particularly complex as Greece does not follow an obvious growth pattern like many European countries.

The issue of regional economic convergence in Greece has been examined in several studies, which often lead to contradictory conclusions. Athanasiou et al. (1995) found that regional inequalities increased during the first post-war decades and subsequently declined. Giannias et al. (1997) and Liargovas et al. (2003) found a weak trend of convergence between regions for the period 1960-2000. Konsolas et al. (2002) also reported the existence of a clear trend of convergence in the income of Greek regions in the period 1989-1994, while Christopoulos and Tsionas (2004) found convergence in terms of labour productivity during the period 1971–1995. Papadas and Eustratoglou (2004), using artificial neural networks, found evidence of convergence for the period 1970-1991.

Unlike the above studies, Siriopoulos and Asteriou (1998) and Petrakos and Rodriguez-Pose (2003), using the β -convergence and the σ -convergence indices, they found divergence between Greek regions for the periods 1971-1996 and 1981-1997, respectively. Additionally, Syriopoulos and Asteriou (1998) reported evidence of

dualism across the south and northern regions. Tsionas (2002) and Fotopoulos et al. (2002), using Markov chains procedures, found strong evidence in favour of club formation, duality and polarisation for the periods 1971-1993 and 1970-1994. Alexiadis and Tomkins (2004) reported evidence of no convergence and the formation of a convergence club for 1970–2000. For a similar period (1971-2003), Benos and Karagiannis (2007) found β -convergence between prefectures but not among regions, while no evidence of σ -convergence is found at both NUTS-II and NUTS-III levels. They also, found that GDP geographic concentration and population density have a negative impact on growth, which outweighs the positive growth effect of population geographic concentration and GDP spatial inequality.

Fotopoulos (2006) examined convergence using stochastic kernel and the associated with it, ergodic density, for the period 1980-2000. The long-run density suggests neither strong polarization nor convergence.

Petrakos and Saratsis (2000) and Petrakos et al. (2005) suggest that regional inequalities have a pro-cyclical character; they are increasing in periods of economic expansion and decreasing in periods of economic recession. Moreover, Petrakos and Saratsis (2000) concluded that there was a tendency towards convergence during 1971–1991. This is also the case in Michelis et al. (2004) who are in favour of regional convergence in 1981-1991 period. Ioannides and Petrakos (2000) attributed spatial imbalances in Greece due to the country's dualistic economic base. In accordance to these results, Psycharis (2008), states that while there is no clear development pattern, there is a positive relationship between the level of economic development and the support that prefectures received. This results in broadening the gap between the most prosperous and the less developed areas in Greece.

The aforementioned contradictory results may exist due to the use of different techniques, at different disaggregation levels (NUTS-II or NUTS-III) and at different time periods¹. Despite of the above results, it is clear that Greece has significant

¹ Additionally and maybe more importantly, there is a measurement problem associated to the limited accuracy of economic data provided by the National Statistical Service of Greece (NSSG) in the cases of Attiki (including the city of Athens) and Thessaloniki prefectures. In the last two decades, the prefecture of Attiki, due to the implementation of decentralized economic policies, has “exported” a significant part of its manufacturing capacity to the neighbouring prefectures of Voiotia and Korinthia. This manufacturing capacity relates to industrial firms established a short distance outside the borders of Attica, but with management, ownership, labour force and resources that come from Athens. This diffusion of Attiki's industrial activity falsifies the statistical data, causing a significant problem in both the evaluation of regional inequalities and the design of proper regional policies (Petrakos and Psycharis, 2006).

spatial disparities that reflect its peripheral position with respect to the core European markets, a lack of adjacency to the ‘single European market’, a highly fragmented economic and physical space and an unbalanced distribution of regional population and activities (Petraikos and Psycharis, 2006).

To study convergence, we follow Carrington (2006) and we implement the stochastic dominance analysis, a method for ranking alternative distributions, which is originally ground on the analysis of decision making under uncertainty. While the stochastic dominance methodology is used to compare the economic results of different portfolios, in our analysis we use this methodology to compare entire distributions of GDP per capita among cross sections, at different time periods. In this sense, this methodology could be grouped along with the distributional approaches. As Carrington (2006) mention, the stochastic dominance analysis offers a more visible link between economic theory and statistical measurement and additionally, it allows the incorporation of location in the analysis.

The stochastic dominance analyses as well as the analysis of stochastic convergence and σ -convergence are applied to the per capita GDPs data for the 51 Greek prefectures (NUTS-III) for the period after the introduction of Greece in the Euro zone, until the year 2007.

The rest of the paper is organized as follows. The next section presents the methodology that we implement, as well as the data we use. Section 3 presents the results and finally in Section 4, we summarize our results and present the concluding remarks.

2. Methodology and Data

The economic convergence literature is dominated by studies of β -convergence and σ -convergence². The β -convergence analysis was initially explored by cross-section regressions (e.g. Barro and Sala-i-Martin, 1991), and later by panel data regressions (e.g. Islam, 1995). Regression analysis has the disadvantage that it only reveals the attitude of the average section. Additionally, it does not provide any evidence about the evolution of the cross-section distribution.

Bernard and Durlauf (1995, 1996), based on regression equations with time-series data, introduced a different version of convergence, the stochastic convergence, which

² For a broad discussion about the convergence analytical tools, see Durlauf et al. (2004).

is present when the long-term forecasts of output for two individuals (e.g. countries, regions) are equal at a specific time. Evans and Karras (1996), employed panel unit root tests, which are more powerful than the time-series unit root tests as they exploit both cross and time series variation, to test for stochastic convergence. In this paper, we apply the panel unit root test provided by Levine, Lin and Chu (2002) (LLC test), that assume a common unit root process among the individuals. Let $i = (1, 2, \dots, N)$ denote the prefectures of our sample and $t = (1, 2, \dots, T)$ the time index. The test for stochastic convergence of the per capita GDP in the prefecture level is based on the following equation:

$$\Delta y_{i,t} = \rho y_{i,t-1} + \theta_t + \sum_{j=1}^{k_i} \varphi_{i,j} \Delta y_{i,t-j} + \epsilon_{i,t} \quad (1)$$

where Δ denotes the annual change of $y_{i,t}$, θ_t represents a common time effect and $\epsilon_{i,t}$ is assumed to be a stationary idiosyncratic shock. The inclusion of lagged differences in the equation serves to control for serial correlation. LLC test allows for variation of the number of lagged differences. The inclusion of a common time effect is supposed to control for cross-sectional dependence caused by an external factor (e.g. a change in EU regional policy). To take control of this effect, we transform the data by subtracting the cross-sectional mean leading to

$$\Delta \tilde{y}_{i,t} = \rho_i \tilde{y}_{i,t-1} + \sum_{j=1}^{k_i} \varphi_{i,j} \Delta \tilde{y}_{i,t-j} + \epsilon_{i,t} \quad (2)$$

where $\tilde{y}_{i,t}$ is computed as

$$\tilde{y}_{i,t} = y_{i,t} - \frac{1}{N} \sum_{j=1}^N y_{j,t} \quad (3)$$

Now, the examination of the stochastic convergence hypothesis is implemented by testing the null hypothesis that all ρ_i are equal to zero against the alternative hypothesis that they are all smaller than zero. The rejection of the null hypothesis (nonstationarity) indicates that the series exhibit mean reverting behaviour and thus implies the existence of stochastic convergence.

In addition to the question of whether regions with high GDP per capita tend to have persistently higher GDP per capita or not, another important aspect of economic convergence is the evolution of the overall cross-regional dispersion of the per capita GDP. According to Barro and Sala-i-Martin (1991) this issue is answered by

exploring the existence of σ -convergence i.e. the evolution of dispersion in a data set over a given period of time. As Barro and Sala-i Martin (1992) claim, ' β -convergence is a necessary but not sufficient condition for σ -convergence'. Moreover, in the presence of σ -convergence, some steady-state value for cross-sectional dispersion would finally be reached (Sala-i-Martin, 1996). The most commonly used measures of dispersion are the standard deviation and the coefficient of variation. Unfortunately, both of these measures are not robust. Distortions from the normal distribution in the dataset, like contaminated observations (e.g. outliers) or heavy tails can largely affect their value. Additionally, σ -convergence cannot distinguish whether the convergence process exists due to movement towards the lower end of the distribution or towards the centre or the upper end of the distribution (Carrington, 2006).

The realization that a single measure of dispersion cannot give the adequate information and cannot reveal the certain characteristics of the evolution of a distribution, leads researchers to apply intra-distributional approaches. Discrete Markov chain analysis and Markov chain analysis using stochastic kernels have been widely used in the last few years. Those methodologies and especially the latter one are very powerful and do not have many of the previously mentioned drawbacks. However, the assumption of an existing law of motion is very restrictive and has inadequate grounding in economic theory.

A rather new analytical tool in the economic convergence literature is the stochastic dominance analysis. While, this analysis is originated in the investment decision making under uncertainty, several applications exist in the wealth distribution literature. Bishop et al. (1991), used the first degree stochastic dominance criterion to compare international income distributions, while Anderson (2004), adapted stochastic dominance techniques to study the extent and the progress of polarization, welfare and poverty of 101 nations over the period 1970-1995. The results of his analysis suggest that polarization between rich and poor countries continued unabated throughout the period under investigation.

Carrington (2006), using the second order stochastic dominance analysis to explore the regional convergence in the European Union from 1984 to 1993, concludes that there is convergence among European regions which is neither fast, nor continuous. Maasoumi et al. (2007), examined the dynamic evolution of the world distribution of growth rates in the per capita GDP using entropy distances and dominance relations

between groups of countries over time and they found strong evidence in favor of polarization and “within group” mobility.

Ahamdanech and García (2007) applied inference-based stochastic dominance methods to study welfare, inequality and poverty in the European Union countries in 2000. Additionally, Ahamdanech et al. (2007) applied inference-based stochastic dominance methods to study the evolution of the per capita income between Spanish regions from 1990 to 2003. Both studies found lack of convergence.

Coes (2008) used the stochastic dominance approach to evaluate the welfare effects of a combination of rising mean income per capita in the context of worsening relative inequality. Finally, Anderson and Ge (2009), investigated the intercity per capita income distribution in China in the 1990’s using the stochastic dominance analysis, and they found significant convergence trends.

The stochastic dominance analysis is suitable for the categorization of risky alternatives of a risk-averse investor. In our case, the connections of the risk-averse investor and the policy-maker are straightforward. A risk-averse investor wants more average expected returns than less, and a low spread of returns relative to a high one. A policy maker in turn, prefers a high average regional income per capita than a low one, as well as low spread of dispersion (convergence) than a high one (divergence). Moreover, for a given level of average per capita GDP, a policy maker prefers convergence to divergence.

As the theory of investment decisions under uncertainty suggests, a policy maker’s utility function conforms the Jensen’s inequalities i.e.

$$U = \{u : \mathbb{R} \rightarrow \mathbb{R}, u'(x) \geq 0, u''(x) \leq 0, \forall x\} \quad (4)$$

For two sets of random outcomes X_1 and X_2 (i.e. two distributions of per capita GDP in different points in time), with cumulative distributions F_1 and F_2 respectively,

$$E_{F_1}(u(x)) \geq E_{F_2}(u(x)), \forall u \in U \quad (5)$$

which holds if and only if

$$\int_{-\infty}^x F_1(u) du \leq \int_{-\infty}^x F_2(u) du, \forall x \quad (6)$$

or over some interval $[a, b]$

$$\int_a^x [F_2(u) - F_1(u)] du \geq 0, \forall x \in [a, b] \quad (7)$$

with at least some strict inequality for some x_0 .

Equation 5 is in fact the requirement for the existence of the first degree stochastic dominance (FSD) while equation 7 is the requirement for the existence of the second-degree stochastic dominance (SSD). It does formally represent the requirement that the area which is enclosed between the two function graphs, should be non-negative up to every point x . Thus, the policy maker will prefer the first distribution of per capita income to the second one, if and only if F_1 (or X_1) second-degree stochastically dominates F_2 (or X_2):

$$(F_1) \geq (F_2) \quad (5)$$

Intuitively, if X_1 and X_2 have the same mean, F_1 is more compactly placed around it than F_2 .

The first and the second degree stochastic dominance criteria frequently provide inconclusive results. Especially the FSD can not discriminate a pair of distribution if at any point, those two distributions cross.

A broader concept than the first and second degree stochastic dominance is the stochastic dominance with respect to a function (SDRF), first introduced by Meyer (1977). This analysis has a more discriminating power than the FSD and the SSD analyses. This power is achieved due to the introduction of bounds on the absolute risk aversion coefficient within a second-degree stochastic dominance analysis. In this sense, one can discriminate among several different risk aversion attitudes. More formally, using the terminology of risk aversion literature, absolute risk aversion coefficient, r_a , can range between r_1 and r_2 . In the case of the FSD analysis, the lower and upper bounds are $-\infty$ and $+\infty$, while in the case of the SSD, 0 and $+\infty$ respectively. The most commonly used forms of utility function that are assumed in the SDRF are the negative exponential utility function and the power utility function³. In our analysis, we apply the SDRF using as lower bound 0 and upper bound $+\infty$, which coincide with the bounds related to the second degree stochastic dominance

³ The former assumes constant absolute risk aversion (by the inclusion of a constant absolute risk aversion coefficient, ARAC), implying that preferences are unchanged if a constant amount is added at all income levels and has the following form: $U(w) = \theta - e^{(-ARAC*w)}$. The power utility function assumes constant relative risk aversion (by the inclusion of a constant relative risk aversion coefficient, RRAC) implying that preferences are unchanged if all payoffs are multiplied by a positive constant (Hardaker 2000). The power utility function has the following form: $U(w) = \frac{w^{1-RRAC}}{1-RRAC}$.

criterion. Thus, in fact SDRF analysis is coincide with the SSD analysis. In this way, we can see how the relevant ranking changes when different risk aversion bounds are assumed. Additionally, the SDRF analysis provides a measure of the ‘distance’ of the examined distribution, from the point of view of the risk averse policy maker. This measure is the Confidence Premium and indicates how much the decision maker would have to be paid to accept the second-rank distribution over the dominant one. The confidence premium is calculated by iteratively adding a monetary unit to each point on the challenger distribution and then checking the decision maker’s SDRF ranking.

The first step for the estimation of the stochastic dominance analysis is the estimation of the non-parametric empirical cumulative distribution function (CDF) for the per capita income distribution in each year. For this reason, we apply the Latin Hypercube method to create simulated series⁴. The next step is the straight estimation of the stochastic dominance criteria⁵.

The data used consists of the per capita GDP of the 51 Greek prefectures (which are equivalent to NUTS-III regions), taken from the National Statistics Agency of Greece and refers to the period 2000-2007⁶. GDP is in annual basis and in real terms⁷.

3. Results

The Levin, Lin and Chu (2000) (LLC) panel unit root test provides strong evidence in favour of convergence (Table 1). The lag lengths were determined by the Schwartz and the Akaike information criteria. Moreover, the spectral estimation was conducted using three different kernels, the Bartlett, the Parzen and the Quadratic spectral. Finally, for the bandwidth selection the Newey-West and the Andrew method were used. According to Table 1, all the possible combinations of the above methods for the implementation of the LLC panel unit root test provide very similar results. Thus,

⁴ We prefer this method relative to the Monte Carlo simulation, as the Monte Carlo procedure randomly selects values from the probability distribution. As a result, the procedure samples a greater percent of the random values from the area about the mean and under samples the tails. On the other hand, Latin Hypercube technique segments the distribution into N intervals and makes sure that at least one value is randomly selected from each interval. The number of intervals, N, is the number of iterations. By sampling from N intervals, the Latin Hypercube insures that all areas of the probability distribution are considered in the simulation.

⁵ All the stochastic dominance analysis was performed using the Simetar© 2008 software.

⁶ We prefer to consider this rather small time period, because according to the Greek National Statistic Agency any broader database that includes such a recent time period (until 2007), would be inconsistent.

⁷ GDP deflators were used to turn the nominal GDP to real GDP (base year: 2000).

we can safely conclude that according to the LLC test, there is a clear stochastic convergence trend.

Table 1. Results of the LLC panel unit roots test.

Lag selection method	Kernel method	Bandwidth selection	t-Statistic	Probability ($\alpha < .05$)	ρ
Akaike	Bartlett	Newey-West	-11.5373	0.0000	-0.4065
		Andrews	-11.0159	0.0000	
	Parzen	Newey-West	-11.8847	0.0000	
		Andrews	-10.9912	0.0000	
	Quadratic Spectral	Newey-West	-12.6343	0.0000	
		Andrews	-10.2023	0.0000	
Schwarz	Bartlett	Newey-West	-11.4663	0.0000	-0.4064
		Andrews	-10.9442	0.0000	
	Parzen	Newey-West	-11.8136	0.0000	
		Andrews	-10.9205	0.0000	
	Quadratic Spectral	Newey-West	-12.5632	0.0000	
		Andrews	-10.1323	0.0000	

Source: Author processing

As we have already mention, stochastic convergence analysis as well as β -convergence cannot reveal the evolution of the cross-section distribution and its certain characteristics. To gather this information, a distributional approach needs to be applied. In Table 2, we provide some summary descriptive statistics of the per capita GDP distributions for each year in period 2000-2007.

Table 2. Summary statistics of the GDP per capita distributions for each year

	2000	2001	2002	2003	2004	2005	2006	2007
Mean	9.2272	9.2565	9.2554	9.3011	9.3238	9.3428	9.3985	9.4126
Std Dev	0.2389	0.2312	0.2268	0.2179	0.2140	0.2153	0.2211	0.2161
Coef. of Variation	2.589%	2.498%	2.451%	2.343%	2.295%	2.305%	2.353%	2.296%
Min	8.8410	8.8549	8.8237	8.9044	8.9332	8.9662	8.9809	9.0402
Max	10.134	10.123	10.035	10.020	10.017	10.000	10.039	10.053
Skewness	1.2490	1.1738	0.9619	0.9655	0.9323	0.7742	0.5177	0.8295
Kurtosis	3.0462	2.9055	1.8738	1.6652	1.6680	1.1055	0.7152	1.1037

Source: Author processing

The standard deviation and the coefficient of variation (CV) are the two commonly used measures of dispersion in the σ -convergence analysis. Although, these measures are not so robust (especially the standard deviation), they are used as indicators of dispersion in the great majority of the σ -convergence studies. In our case, both of

these values indicate an overall σ -convergence, but not with a constant trend. Moreover, in period 2004-2006, both measures of dispersion indicate β -divergence.

The mean value of the distributions is almost constantly increasing across the years (with the exception of year 2002, when it remains constant). So, the GDP per capita is increased on average, after the introduction of Greece in the Euro zone.

In addition, minimum and maximum values indicate that during the examined period, the range of the values is decreasing. More importantly, this decrease is the result of both higher minimum values and lower maximum values, during this period. A closer examination of the data clearly indicates that the lower maximum value is the result of the diminishing of the GDP per capita in Voiotia, a prefecture which has the higher GDP per capita in Greece⁸. On the other hand, very poor prefectures at year 2000, like Arta, Evritania, Ileia and Karditsa present a great increase in their GDP per capita values.

The skewness values indicate that all distributions are right-tailed, i.e. several observations are by far higher than the others. However, the evolution of the skewness value shows a downward trend (with the exception of the year 2007), indicating that there are still extra-ordinary high values but not as discriminating as in the beginning of the period under investigation.

Finally, the value of kurtosis indicates that during the period 2000-2007 (again, year 2007 is an exception) the distribution of the per capita GDP becomes more and more platykurtic and thus the observations are moving away from the middle of the distribution.

Figure 1, provides the probability distribution functions (PDFs) for each year of the period under examination. We construct the PDF graphs⁹ to get an 'optical' view of the distributions and to reveal some of their certain characteristics that cannot arise using the descriptive summary statistics.

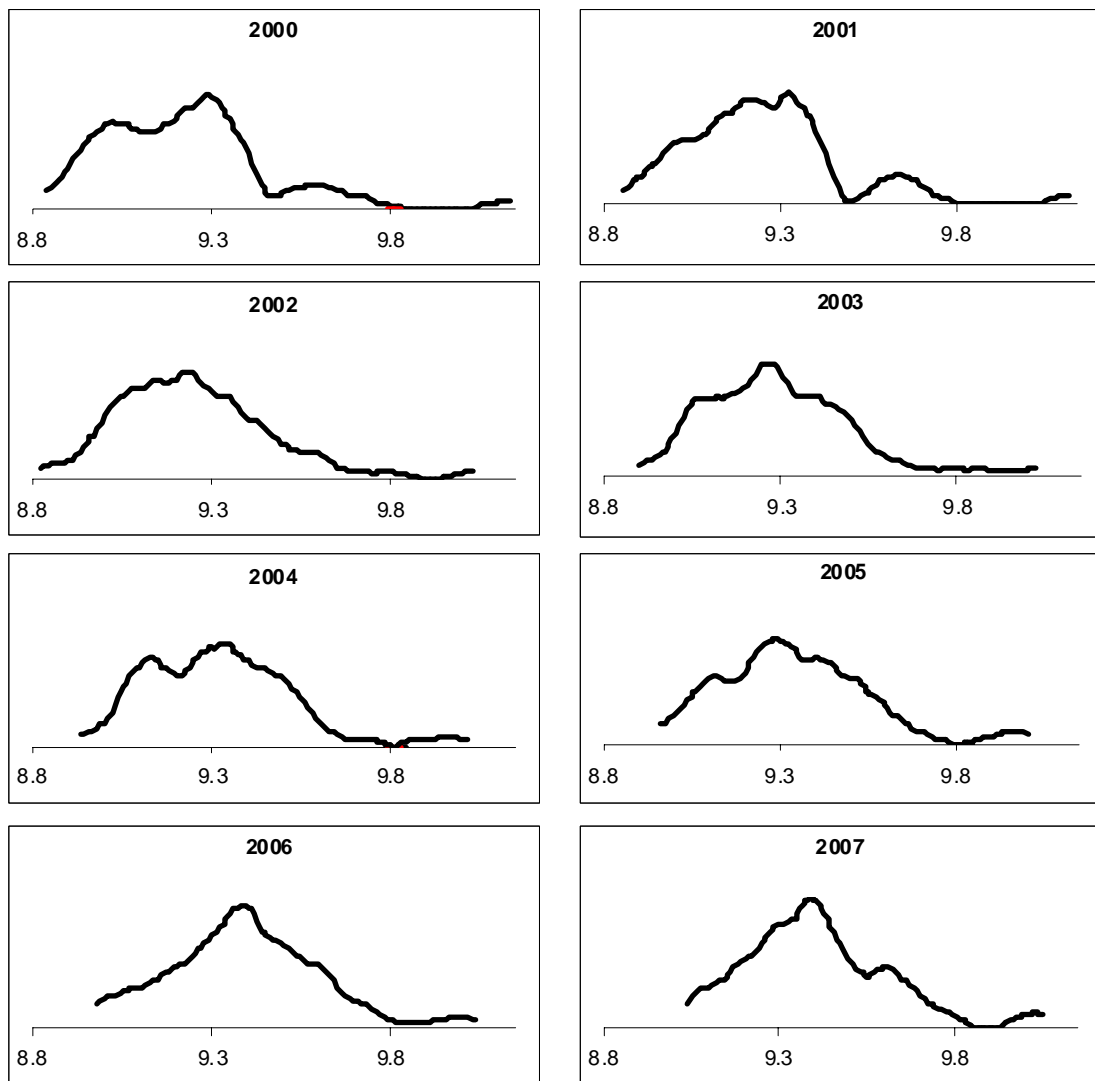
The per capita GDP distributions for years 2000 and 2001 are multimodal while a sharp decline of the probability density function at about 9.5 (natural logarithm of the per capita GDP) appears. This means that very few observations are located in the right side of this point. The shape of the distribution of the per capita GDP changes in

⁸ As we have already mentioned, Voiotia presents very high per capita GDP, because it belongs to the neighbourhood of Athens. However, the last few years, there is a diminishing trend in the real value of the GDP per capita, which is accompanied by a high increase of GDP per capita in Attiki as well as in other neighbours of Attiki like Evoia.

⁹ All PDFs constructed using the Epanechnikov kernel with Silverman's bandwidth selection.

the next two years, where the decline is not so rapid, and the distributions appear to be just right-tailed. The probability density functions of the following two years appear to be much similar to those of 2000 and 2001, but again, no sharp decline in the per capita income level appears. The last two probability densities are quite different from the previous. They appear to be less smooth and additionally in the 2007 distribution, 2 distinctive polars appear.

Figure 1. Probability Distribution Functions of the real per capita GDP (in natural logarithm term)



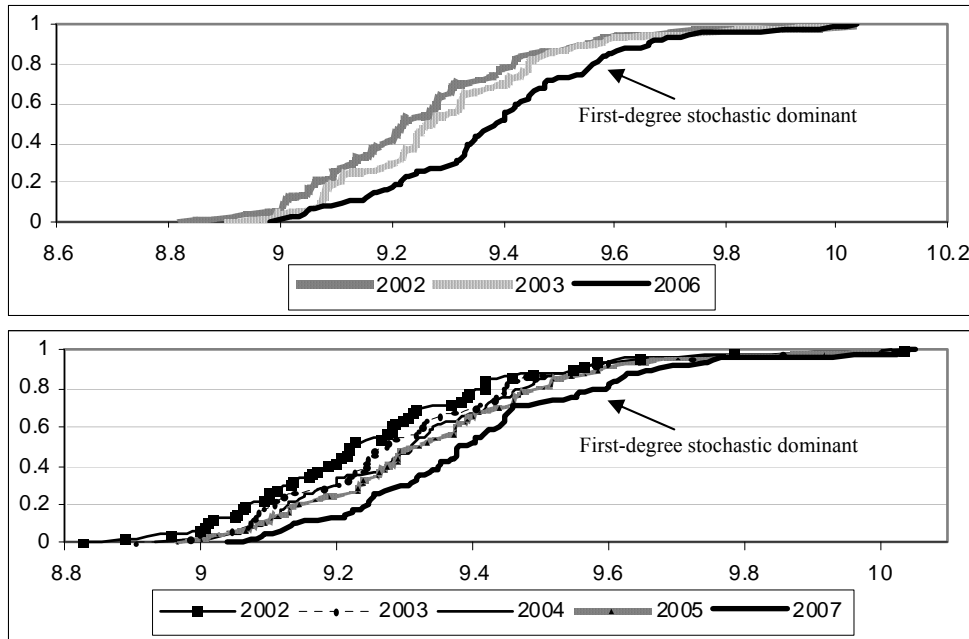
Source: Author's processing

Getting now to the stochastic dominance analysis, the results of the first and the second stochastic dominance criteria are briefly present in Table 3¹⁰. First degree stochastic dominance is presented only in few cases. Specifically, the distribution of year 2007 first-degree dominates the distributions of the years 2002-2005, while the

¹⁰ The analysis was implemented by running 1000 Latin Hypercube iterations.

2006 distribution first-degree stochastically dominates the distributions of years 2002 and 2003 (see Figure 2). On the other hand second-degree stochastic dominance analysis is powerful enough to discriminate the great majority of the possible pairs of distributions.

Figure 2. Cases where First-degree Stochastic dominance exist



Source: Author's processing

However, SSD analysis gives inconclusive results for the pairs of distributions 2000-2002 and 2001-2002 (see Figure 3). In this situation, the stochastic dominance with respect to a function (SDRF) analysis would be more appropriate. As we have already mentioned, in SDRF analysis the risk aversion bounds are restricted to pre-specific levels. The results of this analysis indicate that as the level of risk aversion increases, the preference ordering for the distributions 2000, 2001 and 2002 changes (Table 3).

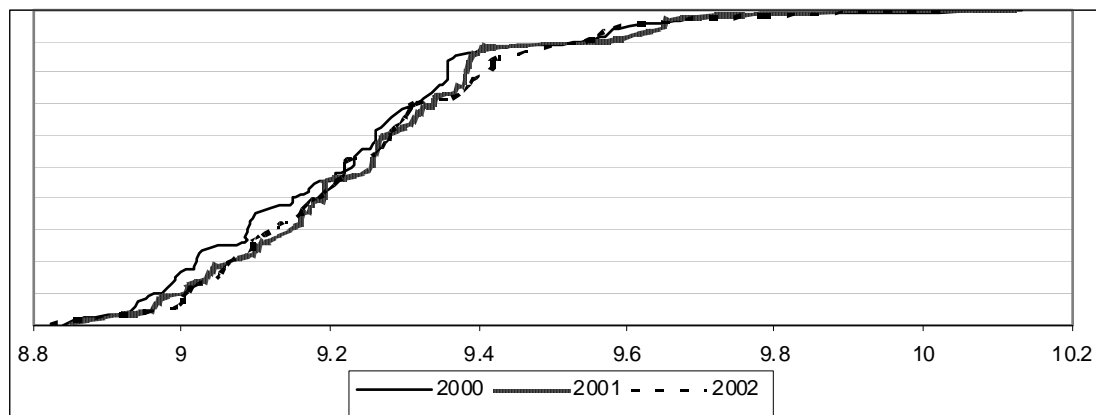
Table 2. First (F) and Second (S) degree stochastic dominance among the yearly distributions

		Dominated							
		2000	2001	2002	2003	2004	2005	2006	2007
Dominant	2000								
	2001	S							
	2002	-	-						
	2003	S	S	S					
	2004	S	S	S	S				
	2005	S	S	S	S	S			
	2006	S	S	F	F	S	S		
	2007	S	S	F	F	F	F	S	

Source: Author's processing

The conclusion from the SDRF analysis is that the level of the risk aversion that characterizes a policy-maker, can determine the relative rank of the distributions. At low risk aversion levels, a policy maker gives more emphasis on the expected income (the average level of the per capita GDP) than in the variation of the distribution. Thus, he is more willing to accept an option of higher average income, even though this options may characterized by increased variation. As the level of risk aversion increased, the willingness of the policy maker to accept a more spread distribution is continuously decreasing.

Figure 3. Two pairs of distributions (2000-2002 and 2001-2002) where SSD analysis provides inconclusive results.



Source: Author's processing

Table 3. Ranking of the per capita GDP distributions relative to the absolute risk aversion coefficient (ARAC)

	ARAC = 0	ARAC > 14.7895 ARAC < 42.4425	ARAC > 42.4425
Relative Ranking	2007	2007	2007
	2006	2006	2006
	2005	2005	2005
	2004	2004	2004
	2003	2003	2003
	2002	2001	2001
	2001	2002	2000
	2000	2000	2002

Source: Author's processing

The level of risk aversion that characterizes a policy maker can be related to the country's specific objectives. When the objective of a country is the improvement of its general economic indicators like the growth rate, a policy maker may not be interested on the spread of income distribution or the possible polarization processes, but only on the general level of the per capita GDP. On the other hand, when the most important policy target is the regional cohesion, an excessively risk averse policy maker could be assumed, whose willingness to accept an alternative distribution with

higher variation is very low, even though this alternative may offer a higher average per capita GDP. This policy target could be achieved by horizontal measures like the development law of 2004 in Greece, which gave incentives for regional development and thus for the elimination of the regional inequalities (Petraikos and Psycharis, 2006).

It is important to mention, that the distributions where the SSD gives inconclusive results, happen to be the three least preferred distributions from the eight under consideration. Additionally, they refer to the first years of the introduction of Greece in the Euro zone. A possible explanation for this result is that after the great effort of Greece to achieve the criteria for the Euro zone accession, no great policy efforts and incentives for investments have been given. This resulted in the absence of convergence trend until the year 2002. In any case, the stochastic dominance analysis clearly indicates that a convergence process among the 51 prefectures in Greece is in progress.

So far, from our analysis, we are not able to understand whether the estimated convergence process is linear, or if it follows a non-linear trend. To get an index of the ‘linearity’ of the convergence process, we estimate the confidence premiums (CP) among the probability distributions (Table 4). In the investment analysis, a confidence premium between a dominant series and a lower ranked alternative is estimated by how much the decision maker would have to be paid to accept the inferior alternative against the dominant. In our case, we interpret CPs as a measure of the ‘distance’ between a pair of distributions. If the convergence process was linear, we would expect the same difference in the CP values between two consecutive distributions. However, this is not the case and thus we can conclude in favour of a non linear convergence process.

Table 4. Confidence Premiums between Probability Distributions

	ARAC* = 0	ARAC > 14.7895 ARAC < 42.4425	ARAC > 42.4425
2007	The most Dominant Distribution		
2006	0.14	0.48	0.65
2005	0.74	0.75	0.8
2004	0.95	0.82	1.12
2003	1.19	1.09	1.41
2002	1.67	1.75	2.26
2001	1.67	1.75	1.96
2000	1.99	2.05	2.14

* ARAC: Absolute Risk Aversion Coefficient
Source: author's processing

It is also important to mention that the results from the stochastic dominance analysis are in accordance with the stochastic convergence approach but not with the results provided by the σ -convergence analysis. While, for the whole period, both standard deviation and coefficient of variation values indicates σ -convergence (as the stochastic dominance analysis also does), the year to year evolution of these values provides different results. σ -Convergence is not present during the period 2004-2006, while according to the stochastic dominance analysis, divergence only occurs in period 2001-2002.

4. Conclusions

In this work, we examine the economic convergence hypothesis of the 51 NUTS-III in Greece, using the stochastic dominance analysis. Economic convergence is tested for the period 2000-2007, using annual data of the per capita GDPs. The results clearly indicate the presence of economic convergence for the whole period under analysis, but not with a constant trend.

The first and the second-degree stochastic dominance criteria were initially applied. In most cases the SSD criterion was powerful enough to discriminate the examined pairs of per capita income distributions. However, in few cases, SSD criterion gives inconclusive results. We further examine these cases by implementing the stochastic dominance with respect to a function (SDRF) analysis. SDRF analysis can reveal how the preference ranking changes when different risk aversion levels are assumed for the policy makers. Finally, we use the confidence premium values (CP) to get an index for the 'distance' between two distributions and thus an indication of the linearity of the convergence trend. Our results suggest that the convergence process does not follow a constant trend as the 'distance' among distributions changed during the years of the period under examination.

The results provided by the stochastic convergence analysis using the Levine, Lin and Chu (2002) panel unit roots test are in accordance with the results from the stochastic dominance analysis. Moreover, σ -convergence exists during the whole period, but the values of both the standard deviation and the coefficient of variation indicate σ -divergence during the period 2004-2006. For the same time period, stochastic dominance analysis indicates convergence.

The stochastic dominance analysis offer the opportunity to the researcher to overcome some problems and limitations related to the traditional methods of convergence

analysis. Regression analysis only reveals the attitude of the average country or region (or in our case prefecture) while it does not provide information about the evolution of the cross-section distribution. This is also a drawback in the σ -convergence analysis which also suffers from frequent distortions from the normal distribution in the datasets, like contaminated observations and heavy tails. Moreover, σ -convergence cannot distinguish whether the convergence process exists due to movement towards the lower end of the distribution or towards the centre or the upper end of the distribution (Carrington, 2006).

In the presence of SSD, the expected returns from the dominant distribution are no less than the one from the dominance one. Moreover, the left tail of the dominate distribution must be thicker than that of the dominant. Therefore, the presence of SSD indicate that not only the income per capita has not fallen, but also that part of the increase, was located to the poorer regions (Carrington, 2006).

The benefits of the stochastic dominance analysis and the ability to take location under consideration by the inclusion of spatial effects could enrich the existing convergence literature. In addition, it can be proved very beneficial, especially for Greece, where as Monastiriotis (2008) claims, the nature of disparities and the regional backwardness appear to be extremely complex. Thus, the only way to sufficiently deal with these issues is to examine the spatial linkages among Greek regions.

Of course, the stochastic dominance analysis is not free of criticism. Its link to economic theory via utility and choice framework is no substitute for a direct link to the existing growth theory. Furthermore, SSD offers no information about the magnitude and causes of the changes identified (Carrington, 2006). The above limitations as well as the usefulness of the other more traditional methodological tools cannot be overtaken. The notion of economic convergence is so complicated and multi-faceted, that only the inclusion of several different methodologies can guarantee that a researcher approaches this economic notion in an adequate degree of understanding.

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