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Environmental Fiscal Effort: Spatial Convergence within Economic Policy on Taxation

Esfuerzo fiscal medioambiental: convergencia espacial de la política económica en materia fiscal

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Abstract

Environmental fiscal effort, when compared with environmental fiscal pressure, represents a far more precise parameter when measuring a country's environmental sacrifice given that it introduces GDP per capita as an analysis variable. This paper focuses on the analysis of convergence in environmental fiscal effort amongst the EU-15 Member States between 1987 and 2008, employing, to this end, the techniques of sigma, beta and gamma convergence. On a complementary level, a spatial autocorrelation study is carried out in order determine whether or not the geographical proximity of countries has any bearing on similar fiscal effort.

Keywords: Environmental Taxes; Fiscal Policy; Spatial Autocorrelation; Moran's Index.

Resumen

El esfuerzo fiscal medioambiental, en comparación con la presión fiscal medioambiental, constituye un parámetro mucho más preciso para medir el sacrificio medioambiental que realizan los países, ya que introduce como variable de análisis el PIB per cápita. Este trabajo se centra en el análisis de la convergencia en esfuerzo fiscal medioambiental entre los países integrantes de la UE-15 para el período 1987-2008, empleándose para ello las técnicas de sigma, beta y gamma convergencia. De forma complementaria se lleva a cabo un estudio de autocorrelación espacial con el fin de determinar si la proximidad geográfica de los países influye en un esfuerzo fiscal medioambiental semejante.

Palabras Clave: Impuestos Medioambientales; Política Fiscal; Autocorrelación Espacial; Índice de Moran.

Clasificación JEL: H23, E62.

1. Introduction

From the early nineties onwards, the incorporation of taxes to achieve environmental objectives has gradually become common practice in the majority of countries. The central idea is to transfer tax burden from earned and unearned income towards inappropriate and excessive use of natural resources and energy products whilst imposing a levy on contamination (Rivas and Magadan, 2010).

Environmental fiscal reforms have enjoyed varying degrees of success: since the publication of Jacques Delors' White Paper on Growth, Competitiveness and Employment in 1993, "green" reform became a concept that was very attractive on a political level, representing a means of simultaneously offering employment, growth and an improved environment (Gago *et al.*, 2014). The initiative was taken by Denmark, Finland, Germany, the Netherlands, Sweden and the United Kingdom, where green elements have been introduced into fiscal reform over the course of recent decades. This trend of "greening" taxation (eco-tax reform) was gradually adopted in the remaining Member States (Von Weizsäcker, 1994), some of which to a large extent motivated by the process of accession to the EU, although with highly different levels of environmental fiscal pressure and effort.

In the design of a sustainable environmental policy for the EU (European Commission, 2007), two types of market instruments have been considered: on the one hand, instruments focused on modifying prices, primarily taxes (which increase the prices of products and services). Such instruments are primarily designed to raise revenues, to provide financial or fiscal incentives (through price reductions) and to change the behaviour of producers and/or consumers. Secondly, market instruments may also act on quantities, determining the maximum amount of a substance that may be produced, by means of systems of tradable permits (Quesada *et al*. 2010, 2011).

Fiscal pressure and fiscal effort are concepts that are terminologically closely related; however, there are subtle differences, whereby they are to be treated in an entirely different manner. Environmental Fiscal Pressure, hereinafter EFP, refers to the percentage of participation of tax collection, in this case all revenue deriving from environmental tax, within the Gross Domestic Product, which can be expressed as follows:

$$\text{EFP} = \left[\frac{\text{Environmental Tax Revenue}}{\text{GDP}}\right] \times 100$$

Environmental taxes can be divided into three large groups: energy taxes, which account for approximately three quarters of overall environmental taxation; transport taxes, accounting for close to a quarter of total environmental tax revenue; and a third group, taking in two types of taxes with a more modest impact on collection, namely tax on contamination and tax on natural resources, which represent approximately 5% of environmental taxes.

For its part, fiscal effort is most commonly defined as the relationship between taxes paid and theoretical taxation capacity. Fiscal effort must measure the "sacrifice" that payment represents for the contributor (Suárez and Fernández, 2008): the underlying idea is that, as in the case of fiscal pressure, sacrifice, and consequently fiscal effort, is greater amongst individuals with low incomes as they are forced to forego consuming goods of greater necessity than those renounced by contributors with higher incomes. The controversy centres on the difficulty of establishing a common criterion with regards to taxation capacity.

In this paper, we adhere to the definition of fiscal effort proposed by Frank (1959), more specifically, considering overall environmental taxes, GDP and population as relevant variables. Therefore, Environmental Fiscal Effort, hereinafter EFE, is the quotient between EFP and GDP per capita, which can be expressed as follows:

$$EFE = \left[\frac{Environmental\ Tax\ Revenues/_{GDP}}{GDP/_{Population}}\right] \times 100$$

Having pointed out the differences between these two variables, the objective of this study is twofold: on the one hand, focus is placed on the analysis of absolute convergence within EFE, employing, to this end, the techniques of sigma, beta and gamma convergence, taking the EU-15 countries as a reference in the period between 1987 and 2008. On the other hand, spatial dependency analysis is carried out (Ripley, 1981; Hainin, 1990; Cressie, 1993; Tiefelsdorf, 2000) wherein the countries are no longer considered as independent geographical units, but rather as constituent parts of a specific area. This analysis will enable us to determine whether or not the presence of a specific EFE value in a certain location within this space produces greater (or lesser) affinity amongst the same or similar values in the area surrounding this location (López and Palacios, 2000).

The paper is structured as follows: an introductory section that defines the subject matter and presents the basis of the distinction between the extremely important concepts of environmental fiscal pressure and environmental fiscal effort; a second section detailing the methodology employed, both in the absolute convergence analysis and the spatial dependency comparison; and a third section that presents the results of the study and finally the conclusions.

1. Methodology

As stated above, this second section involves a brief analysis of the three absolute convergence techniques employed (sigma, beta and gamma convergence), before focusing on spatial dependence in greater detail.

Most studies focusing on convergence have employed traditional beta, sigma and gamma convergence techniques, either by means of cross-sectional analyses, or by using time series, as reported by Cendejas *et al.* (2013), Young *et al.* (2008) and Quah (1996). In all these studies, variables related to economic growth are used as reference variables in the analysis of convergence. However, in terms of traditional convergence limited studies have been undertaken on fiscal convergence (Esteve *et al.*, 2000; Delgado, 2009, 2013; Sosvilla *et al.*, 2001; Villar *et al.*, 2015; Gemmell and Kneller, 2003; Annala, 2003; Kočenda *et al.* 2008) and fewer still have applied unit root analysis (Villar and Huete, 2016; Delgado and Presno, 2010; Esteve *et al.* 1999) despite its great importance within the framework of economic integration and fiscal harmonisation.

β convergence. The hypothesis of β convergence makes reference to the inverse relationship between the rate of growth of a certain magnitude and its initial level. β convergence can be expressed mathematically via the following equation (adapted from Barro and Sala-i-Martin, 1992):

$$\ln\left(\frac{y_{i,t}}{y_{i,0}}\right) = \alpha + \beta \ln(y_{i,0}) + u_i \qquad [1]$$

on the basis of cross-sectional data, wherein is the EFE of country i (i = 1,...,15) in year t, measured in real terms, T = 21 is the duration of the study period, α and β are the parameters to be calculated and is a random error term.

The existence of β convergence would indicate a negative relationship between the rate of growth over the 1987-2008 period and the initial level of fiscal effort, which implies that the β parameter of the linear regression must be a negative magnitude and statistically significant. The β parameter allows us to measure the speed of convergence, whereby, the higher the value of β, the greater the speed at which countries converge, calculating the speed of β-convergence in the following manner:

$$r_b = \frac{\ln(\beta+1)}{(-T)} \qquad [2]$$

σ convergence. σ convergence occurs where the dispersion of the variable of interest in the "n" of countries analysed tends to diminish over time. In order to measure this dispersion, a relative dispersion measurement is normally employed, such as the coefficient of variation (CV):

$$CV_t = \frac{\sigma_t}{\bar{y}_t}$$

where $\bar{y}_t = \frac{1}{n}\sum_{i=1}^{n} y_{it}$; $\sigma_t = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_{it} - \bar{y}_t)^2}$ [3]

Furthermore, to analyse the trajectory of σ convergence, the annual rate of σ convergence was calculated, understood as the percentile change occurring within CV on an annual basis. Moreover, the existence of σ convergence can be verified via the regression of the dispersion measurement over time:

$$CV_t = \alpha + \beta t + \varepsilon_t \quad [4]$$

Thus, the parameter indicates the existence of σ convergence where it is less than zero ($\beta < 0$), σ divergence where ($\beta > 0$), or stability where ($\beta = 0$).

Barro and Sala-i-Martin (1992) demonstrated that the concepts of σ convergence and β convergence are related, whereby the existence of beta convergence is a necessary but insufficient condition for the existence of sigma convergence, whilst σ convergence is a sufficient, but not a necessary condition for β convergence (Furceri, 2005; Wodon and Yithaki, 2006).

ɣ convergence. ɣ-convergence was a concept proposed by Boyle and McCarthy (1997 and 1999), as a complement to sigma convergence. For a group of countries to evidence ɣ-convergence, mobility must exist within the distribution over time that enables alteration of their ranking. To this end, the binary version of the Kendall index of rank concordance (RC) is employed (Siegel, 1956), expressed, in order to compare the ranks at point *t* and point 0, in the following manner:

$$RC_t = \frac{\mathrm{var}[R(y)_{it} + R(y)_{i0}]}{\mathrm{var}[2R(y)_{i0}]} \quad [5]$$

where is the position or rank of country *i* in year *t*. This index ranges from 0 to 1 wherein proximity to 0 indicates a greater degree of mobility within the distribution and, therefore, a higher level of convergence. In order to analyse the significance of gamma convergence, attention is focused on whether or not the statistic follows a chi-squared distribution with an n-1 degree of freedom.

Spatial dependence. In the analysis of the spatial dimension of the data, the regions are no longer considered as independent geographical bodies in order to incorporate the possibility of spatial interaction (Rey and Montouri, 1999). Spatial autocorrelation can be defined in a number of manners: Sokal and Oden, (1978), Tobler, (1979), Upton and Fingleton, (1985), Toral (2001); following Cliff and Ord (1973), it can be defined in this manner – "if the presence of some quantity in a county (sampling unit) makes its presence in neighbouring counties (sampling units) more or less likely, we say that the phenomenon exhibits spatial autocorrelation." Moran's Index (Moran, 1948, 1950) is

commonly employed to measure spatial autocorrelation, calculated via the following equation:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\,(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \quad [6]$$

where n is the number of countries (n = 15) and $W = (w_{ij})$ is the matrix of spatial weights that determine the degree of contiguity between zone i and zone j. In this paper the w_{ij} contiguity measurement is considered as the inverse of the distance between capitals in each of the countries analysed. The values of Moran's index oscillate between +1 (representing a strong positive spatial correlation) and -1 (representing a strong negative spatial correlation), whilst the index values will be close to zero where no spatial correlation exists.

The Environmental Fiscal Effort (EFE) index data was calculated from the variables de environmental tax revenues (energy, transport, resources and pollution taxes), Gross Domestic Product (GDP) and population, obtained from the online Eurostat database for the period 1987-2008. The starting year corresponds to the year in which the Single European Act, which laid the groundwork for further advances in the field of fiscal harmonization. The fifteen[1] EU countries that are the subject matter of this study were selected according to the time criterion of when they joined the EU, as well as by homogeneity criteria, since the tax structure and economic development of the thirteen countries that joined after 1995, and which make up the current EU-28, are quite heterogeneous, which means that their inclusion in the study would significantly distort the results of convergence analysis.

3. Results

3.1. Absolute Convergence Results

Analysis of absolute convergence demonstrates, firstly, the existence of β convergence within EFE for the fifteen countries considered in the study, the results obtained from the equation [1] via the estimate of ordinary least squares (OLS) is presented in the upper section of Table 1, where it can be seen that the beta parameter is negative and significant. Attention should also be drawn to the good adjustment of the model (R^2 = 0,742). The speed at which countries converge is established as 5.71%, which implies that, at this rate, the differences between EFE values will be reduced by half in approximately 13 years.

[1] Belgium, Germany, France, Italy, Luxembourg, Netherlands, the United Kingdom, Ireland, Denmark, Greece, Spain, Portugal, Austria, Finland and Sweden.

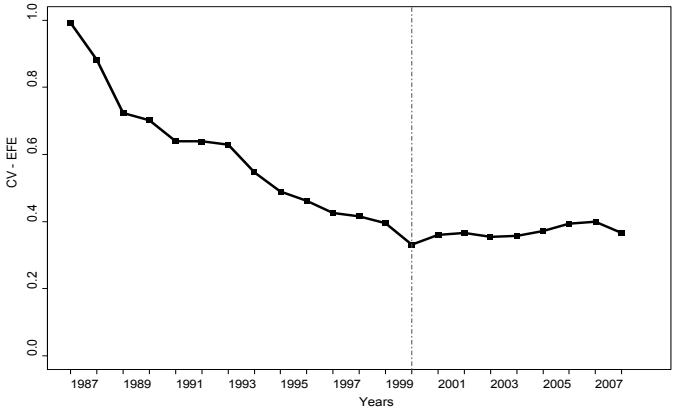
TABLE 1: β AND σ CONVERGENCE REGRESSION IN EFE FOR THE EU-15. 1987-2008

β convergence (OLS)					
1987-2008	α	β (S.E)*	p-value	R^2 (S.E)* *	Speed of β convergence
EFE	-3.736	-0.699 (0.114)	0.000	0.742 (0.319)	5.71%
σ convergence (CV)					
1987-2008	α	β (S.E)*	p-value	R2 (S.E)* *	Annual rate σ-convergence
EFE	52.265	-0.026 (0.003)	0.000	0.768 (0.095)	-4.37%

Source: Calculated by authors based on Eurostat data.
Notes: * The standard errors of β are in parentheses.
** The standard errors of the regression are in parentheses.

With regards to σ convergence, as Figure 1 illustrates, there is a clear convergence process between 1987 and 2000, wherein the CV is reduced by 66.7%, with an annual σ convergence rate of 8%. From 2000 onwards, the situation is characterized by a period wherein stability predominates, with a slight tendency towards divergence. Considering the 1987-2008 period globally, a process of σ convergence exists, as shown by the results derived from the equation [4], presented in the second section of Table 1, with a negative and significant beta parameter and an annual convergence rate of 4.37%.

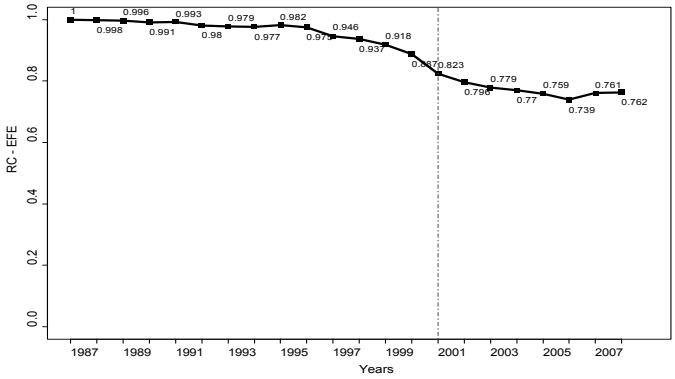
FIGURE 1: σ CONVERGENCE IN EFE WITHIN THE EU-15. 1987-2008



Source: Drawn up by the authors. R-project design.

The results relating to ɣ convergence, represented via the evolution of the Kendall rank index, equation [5], demonstrate the existence of ɣ convergence, as shown in figure 2, with the corresponding mobility in the order of the countries over the years, proving significant from 2001 onwards wherein RC presents values that are significantly different from 1: the critical value obtained via the contrast statistic was 0.8459.

Figure 2: ɣ convergence in EFE within the EU-15. 1987-2008



Source: Drawn up by the authors. R-project design.

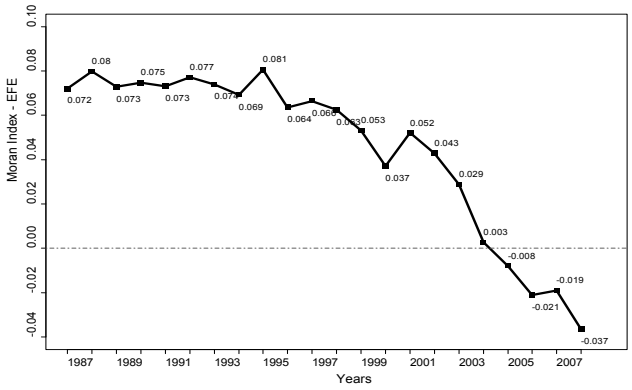
3.2. Spatial autocorrelation results

The results of the spatial autocorrelation study are presented in figure 3, wherein the global spatial autocorrelation index, "Moran's Index" (equation 6), are presented for each year in the series. Moran's index progressively diminishes with values ranging between -0.04, in 2008, and 0.08, in 1995. As the values are very close to zero, it can be concluded that there is no spatial autocorrelation amongst the EFE values.

Null spatial autocorrelation implies that the EFE value for each country over the years does not follow any set pattern, whereby, the series of data referring to environmental fiscal effort present geographical localisation that would be similar to that obtained via a random assignation for each country *i* in the study area.

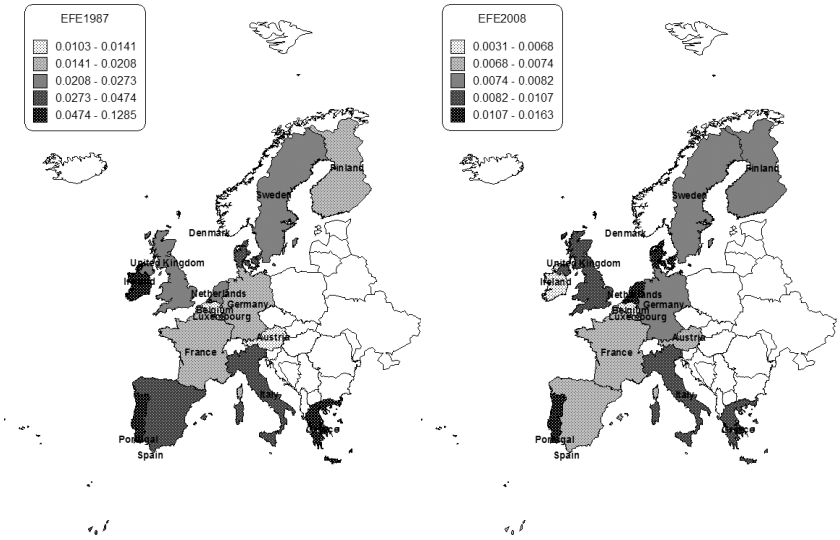
These numerical results corroborate the lack of spatial autocorrelation of the environmental fiscal effort values that each of the countries presents, as Figure 4 indicates. On the map, for both the initial and final year of the series, it is observed that the geographical proximity of the countries does not cause them to present similar EFE values.

FIGURE 3: SPATIAL AUTOCORRELATION. MORAN'S INDEX FOR EFE.



Source: Drawn up by the authors. R-project design.

FIGURE 4: GEOGRAPHICAL DISTRIBUTION OF EFE IN THE EU-15. 1987 AND 2008



Source: Produced by the authors using the program MapViewer 7.

4. Conclusions

This paper has described the concept of Environmental Fiscal Effort and provides grounds in favour of the relevance of this concept, from both fiscal and environmental perspectives. With the objective of determining the degree of proximity of the EU-15 countries in terms of this variable, absolute convergence analysis was carried out, whilst simultaneously studying the possible influence of the geographical location of the countries to analyse the similarity of the values found in each territorial unit. The analysis made of environmental taxation in the EU-15 countries was focused on three groups of taxes: on energy, transport and pollution. There was found to be a clear predominance of energy taxation, which accounted for three-quarters of the total environmental tax collection.

The reasons for using environmental taxes, are among others, as observed by the European Environment Agency (1996): a) they are particularly effective instruments for the internalisation of externalities; b) they can raise revenues which may be used to increase environmental expenditure; c) they can be particularly effective policy tools to tackle environmental priorities from "diffuse" pollution sources such as transport emissions, waste and the chemicals used in agriculture.

The existence of β convergence was confirmed, which implies that the differential between EFE values amongst countries is progressively reduced, coming close to an annual speed of 5.71%. With regards to sigma convergence analysis, over the course of the twenty-two years taken in by the study, a σ convergence process exists, particularly in the period between 1987 and 2000 wherein the dispersion values of the studied variable are reduced much more intensely to a rate of 8%, whilst this tendency changes towards stability/divergence from 2000 onwards. Finally, the γ convergence results conclude with clear mobility in the order of countries and gamma convergence proves significant from 2001 onwards.

On the basis of the spatial analysis of the data carried out via Moran's Index, it can be concluded that no spatial autocorrelation exists amongst the environmental fiscal effort values in the fifteen EU countries that were studied. This implies that in the localisation of the observations there is no latent information relating to observations in the neighbouring area.

Countries in which tax reform is still at a very preliminary stage must take urgent steps to integrate environmental issues into the mainstream of government policies. Not only environmental, but also economic and social aspects of sustainability must be taken into account, and citizens and businesses should be involved in this process, seeking to achieve a real change in behaviour patterns. And this should be done in terms of Europe-wide regulation, thus forming the basis for a new process of tax harmonisation with respect to environmental issues, unifying the design of environmental taxes as a whole: tax design, tax target, tax outcome.

These reforms should be coordinated at European level in order to avoid isolated attempts to internalise external effects, which would only serve to

undermine the competencies of the European fiscal systems. In this regard, several Community guidelines have been approved with a view to laying down a framework for environmental taxation reforms. The most recent of these is the "Seventh Environment Action Programme of the European Community", the new general Union Environment Action Programme to 2020, entitled "Living well, within the limits of our planet". Through this Programme, the EU has agreed to step up its efforts to protect our natural capital, stimulate resource-efficient, low-carbon growth and innovation, and safeguard people's health and wellbeing – while respecting the Earth's natural limits.

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