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A STUDY OF PUBLIC SPENDING ON HIGHER EDUCATION INSTITUTIONS IN EUROPE IN THE FRAMEWORK OF THE BOLOGNA PROCESS USING STATISTICAL FITTING WITH SPATIAL ANALYSIS

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Abstract

Background and objective. The conventions adopted by the European Higher Education Area (EHEA) are giving way to inevitable changes with regard to costs, structures and organization in the broad context of the systems involved. With the effective enactment of the EHEA, it is productive to analyze the costs of this process of change, as well as to measure and evaluate the impact that such investments have in each of the countries. As a consequence, the goal of this study is to identify significant relationships between public spending on higher education and some economic and social variables that may lead to proposals for improvements in the system.

Method. Starting with the available data, a spatial analysis is performed with the intention of studying public spending on higher education in EHEA member countries. The macroeconomic variables utilized (for the last year) are the stoppage and inflation rates, the college-aged population, the percentage of individuals registered in the university system, the total number of graduates and the number of university professors.

Results. The analysis shows that public spending on higher education, in the form of investment, varies among European countries. The analysis allows for the identification of several groups as a function of statistically significant differences, depending on the country being examined.

Conclusions. All of the variables of the proposed model, both dependent and independent, can be associated with different groups of spatial dependence patterns. The analysis presented allows for an identification of significant spatial distribution trends in spending on higher education.

1. Introduction

The process of adapting to the European Higher Education Area (hereafter, EHEA) significantly affects the university education system in its organization, costs and structure. Therefore, it is a compelling subject of study and analysis from the standpoint of adaptation and management change.

It is important to note that the higher education sector comprises, on average, nearly 1.1% of the gross domestic product (hereafter, GDP) (2007) in the countries of the Organization for Cooperation and Economic Development (OCED). This value reaches 4.8% when all education levels are taken into account.

The beginnings of this process of educational change date back to 1998, when the ministers of education of France, Germany, Italy and the United Kingdom signed a declaration. At that point, the declaration was intended to start the process of long-term change in higher education in Europe. In the following year, the Bologna Declaration established the objectives and patterns to be followed by countries that signed the accord. This change sought to achieve unifying goals, such as the recognition of degrees obtained in any country belonging to the EHEA, homogenizing the structure of conferred academic degrees and the credit system, creating and promoting mobility programs, guaranteeing the quality of studies and promoting permanent learning. Until now, each country had been developing its own advances, mechanisms and tools for achieving efficiency in higher education.

The adaptation process that began with the Bologna Declaration in 1999 is reaching its end. The year 2010 was the endpoint foreseen by the Declaration for the complete achievement of its goals. It is important to analyze the costs of this process and to measure the impacts brought about by the investments made in each of the countries. For example, if spending on higher learning in the EHEA countries as a percentage of the GDP is compared before and after the enactment of this accord, it can be seen that there is a slight positive trend, which can be explained by the efforts that are being made to fulfill the commitment to the Bologna Declaration (Table 1).

Table 1. Spending on higher education as a percentage of the GDP

	2007	2000	1995
Austria	1.3	1.1	1.2
Belgium	1.3	1.3	-
Denmark	1.7	1.6	1.6
Finland	1.6	1.7	1.9
France	1.4	1.3	1.4
Germany	1.1	1.1	1.1
Greece	-	0.8	0.6
Hungary	0.9	1.1	1.0
Ireland	1.2	1.5	1.3
Italy	0.9	0.9	0.7
Netherlands	1.5	1.4	1.6
Norway	1.3	1.2	1.6
Poland	1.3	1.1	0.8
Portugal	1.6	1.0	0.9
Slovak Republic	0.9	0.8	0.7
Spain	1.1	1.1	1.0
Sweden	1.6	1.6	1.5
Switzerland	1.2	1.1	0.9
Turkey	-	0.8	0.5
United Kingdom	1.3	1.0	1.1
Estonia	1.3	1.0	1.0
Slovenia	1.3	-	-

Source: OCED

The countries are not all in the same phase of adaptation to this process and are not adapting in the same way, nor did they start with the same educational structures. The cost structures are diverse because higher education in each country currently has its own traditions and rules that are presently in the unification process. Therefore, the previous data comprise the start of this study, which attempts to analyze the reasons for these differences.

Keeping in mind that the changes under the umbrella of the EHEA for the signatory countries are derived from the economic realm, it is revealing to analyze the variation in spending and costs that the European countries have experienced, as well as the social and economic effects that have resulted from the EHEA.

Many studies in the recent literature have focused on the process of establishing various major fields, accompanied by the granting of academic degrees (Virgós [17], Martín et al. [13], Marta and Vadillo [12], López-Cózar and Priede [11]). However, there have been no economic analyses centered on the costs of this process.

Relevant and economics-based studies on this topic by a few authors in Spain and Europe (there are also various partial studies by American and British authors, including Riew [14], Cohn [1], Trow [16], Levin [10], Johnes [9] and Thanassoulis et al. [15]) provide an excellent resource for deeper knowledge in this area.

2. Goals

The goal of this study is to examine variability in the distribution of public spending on higher education and to identify the existence of similar or divergent patterns for the 31 European countries[1] involved. To this end, spatial analysis, a novel and recently developed technique, was used, as explained below. Because of its novelty, there has been little application of spatial analysis in scientific works to date.

[1]The European countries included in the analysis are (in alphabetical order): Austria, Belgium, Bulgaria, Cyprus, The Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania*, Luxembourg, Malta, The Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and The United Kingdom.

*The case of Lithuania deserves an additional comment because, although it is not yet part of the EHEA, it was included in the analysis because of information limitations of the software program that was used for the spatial statistics, which does not allow the elimination of countries from the original map.

In response to the literature on this topic, the hypotheses here are based on the existence of positive correlations between public spending on higher education and the unemployment rate, the rate of inflation, the college-aged population, the percentage of students registered in college and the number of university professors. In contrast, a negative correlation is expected between the dependent variable and the total number of graduates in the university system. By applying spatial analysis, this study attempts to identify the existence of significant relationships between public spending on higher education and economic and social variables, which may lead to proposals for improving the system. Finally, a model is proposed in which the public spending on university institutions and administrations, measured as a percentage of the GDP, depends on certain exclusively educational variables and other macroeconomic factors.

Based on statistical and mathematical methods, and using maps, geographical information systems (GIS) and several simulation tools, spatial analysis reveals recurring structures and forms of spatial organization. These structures and forms summarize, for example, center-periphery models, gravitational interaction fields, urban plot hierarchies and different types of networks or terrains. Most recently, the advantages of this technique have been used in disciplines other than geography (the research environment that has used it the most), with spatial econometrics (or regional science), history, agriculture, archeology and environmental science being the most common. Additionally, it should be noted that there have been applied studies (Enciso et al. [4], Florax [5] and García [6]), including the current article, in the realm of education economy, investigating topics such as the economic impact generated by universities, relationships between innovative activities and the transfer of knowledge. These studies enhance our knowledge of the relationship of variables that are linked to the university realm and their impact on society. However, following Enciso et al. [4], it is worth noting that there are several methodologies related to the spatial dimension, such as the input-output model and interregional and integrated Keynesian multiplier models, that are concerned with the impact of university spending on the regional economy.

3. Methodology

The phenomenon explored in this work is analyzed from a spatial perspective (Jaría et al. [8]). This approach is used to characterize the attributes of the objects being studied and is involved in the characterization of spatial forms, such as descriptions of the nature and intensity of relationships, grading of similarities, and so on. When the variability of a specific phenomenon is studied as a function of other factors, it may suffice to use statistical models (such as multiple regression, analysis of variance and covariance and logarithmic models), depending on the nature of the endogenous and exogenous variables. However, there are different levels of spatial integration in statistical treatments, depending on the methods used and the attributes selected to characterize the objects studied. The determination of distances is one of the fundamental bases of statistical techniques, which, in conjunction with the probability models used, yield inferential and statistical decision logic, whether in the Fisher or Bayesian realm. To amplify and treat in detail the application of the methodology and the mathematical formulation on which the spatial analysis is based, the work of Jaría et al. [8] can be consulted because it applies this technique to the entirely different realm of sanitation.

This work evaluates the pattern – local and global – of the dependent variable, as well as of the different independent variables, with the goal of analyzing the possible existence of a statistically significant spatial autocorrelation. In this case, the spatial analysis is performed in two stages: an exploratory and a confirmatory stage. The first stage is used to analyze whether the dependent and various independent variables follow some specific pattern of behavior. To this end, graphic tools such as quantity maps or box-maps are used (as they explore the observed distribution of each variable). In addition, the possible existence of statistically significant spatial autocorrelation is explored; for this, the standardized statistical parameter known as “Moran’s I”, which is derived from the simulation of “*k*” samples from the original data, is used. This procedure is based on obtaining the aforementioned statistical parameter for each of the “*k*” samples and deriving

its standard error and, with this, its statistical significance ("leave-one-out" sampling model), which in this case was specified in $k = 999$ simulations. The normalization of this statistical parameter yields to the need to fix the variability of the norm to make its interpretation easier, as is normally done for different correlation coefficients. To complete this first stage of exploratory analysis, and once the behavioral schemes have been analyzed at the global level of the variables, it is necessary to detect whether there is some specific behavior of these variables at the local level, as a variable may be randomly distributed at the global level while there are observations that display spatial autocorrelation at the local level. To analyze this phenomenon, one of four common tools was used: specifically, the *cluster map*, which detects statistically significant local behavior.

By exploring the variables specified in the model and foreseeing that there may be problems of spatial dependence, the methodology proceeds to the second and last stage of spatial analysis. The goal of this second stage is to estimate the model using ordinary least squares (OLS), to analyze whether the proposed independent variables predict the behavior of the dependent variable and to determine whether the specified model is valid (or if it must be discarded in favor of another that accounts for spatial dependence). For the positive and negative correlations that are statistically significant, the size of the "*r*" given by Cohen's $(r = l/n - 1)$ statistical parameter was determined; a value higher than 0.80 indicates a high-intensity effect.

3.1. Variables analyzed

For each of the European countries studied, the variable "public spending on university institutions and administrations" was recorded as a percentage of the GDP, either as a dependent or independent variable. In addition, as predictive or independent variables of public spending, macroeconomic variables such as the unemployment and inflation rates were used. The total college-aged population, the percentage of students registered in college[2], the

[2]These variables, concerning the university realm, refer to levels 5 and 6 of the International Normalized Ranking of Education (INRE) established by UNESCO.

total number of graduates and the number of university professors in the system were used as variables to represent the university educational environment.

The aforementioned variables were recorded for all of the European countries for the year 2008[3]. The two main sources of information for these data were Eurostat (Statistical Office of the European Community) and UNESCO (United Nations Educational, Scientific and Cultural Organization).

For the statistical program predictions, the variables can be analyzed as both absolute and relative variables. The dependent variable, public spending on university institutions and administrations, was taken as a percentage of the GDP of each country. Rates were used as measures of the independent macroeconomic variables of unemployment and inflation. The independent variables that are strictly related to education, the college-aged population, the total number of university graduates and the number of university professors (counting both full-time and part-time faculty) are expressed as absolute values. The final variable, the students registered in the university system, was expressed as a percentage of the total college-aged population.

4. Results

The exploratory analysis, at the global level, of the respective maps shows that the dependent variable, spending on university institutions and administrations, shows a positive spatial dependence because of the clear association among similar variables in the region being analyzed. According to the result obtained from the box-map of this variable, it can be stated that the analyzed countries show a similar behavior at the general level and that no country stands out as having a behavior different from that of the rest.

The independent variables of the proposed model all display a situation very similar to what was observed with the interpretation of the quantity

[3]For cases in which there were not sufficient data for the base year mentioned, the latest available published data were used.

maps of the dependent variable. Intuitively, it appears that all of them have a positive spatial dependence because similar values prevail in nearby areas within the region. However, the box-maps of some predictive variables yield interpretations of atypical behaviors that deserve comment. With regard to the inflation rate, countries such as Iceland, Estonia, Latvia and Bulgaria exhibit extreme spatial variables with respect to the upper tail. In other words, they show values that are greater than those of their neighboring countries. With regard to the college-aged population, it is worth noting that its atypical behavior is the same as that of the independent variable mentioned previously. In other words, some countries (France, Spain, Italy, The United Kingdom, Germany and Poland) stand out by having extremes that are greater than those of the rest. Other variables for which countries stand out relative to their neighbors are the number of university graduates (Spain, The United Kingdom, Italy, Germany, Poland and Romania) and the number of university professors (Spain, The United Kingdom, Germany, Poland and Italy). In contrast, the opposite was found for the percentage of students registered in higher education institutions, where Germany stands out by having atypically low values.

Analogous to the last step, the existence of spatial autocorrelation for both the dependent and independent variables is analyzed, this time by obtaining Moran’s I statistical parameter, which gives the sign of the existing dependence. For the majority of the variables, it appears, at first glance, that there is some spatial autocorrelation (in some cases positive and in others negative). However, in some cases, the spatial dependence appears to be slight or non-existent. Table 2 shows a summary and comparison of the results of the 999 random permutations. Thus, it is statistically possible to conclude whether there is spatial correlation, and in the affirmative case, the sign (positive or negative) can be interpreted.

Table 2. Summary of the results with the indication of Moran's I value, its significance, size effect and interpretation summary

Dependent and independent variables	**Moran's I statistical parameter with its significance in parentheses**	**Size effect** $(r_i)^{***}$	**Interpretation**
Public spending on university institutions and administrations as a % of the GDP	$0.0980\ (p = 0.2150)$	$r = 0.01$	A very slight significance showing a very small positive effect
Unemployment rate	$0.1086\ (p = 0.1740)$	$r = 0.02$	Slight significance implying that the unemployment rate influences the spatial distribution of spending on higher education
Inflation rate	$0.2851\ (p = 0.0280)^{**}$	$r = 0.24$	Moderate effect showing that the rate of inflation significantly explains the spatial distribution of spending on higher education
College-aged population	$0.1424\ (p = 0.1070)^{*}$	$r = 0.12$	Low effect showing that the college-aged population significantly explains the spatial distribution of spending on higher education
Percentage of individuals registered in higher education institutions	$0.0351\ (p = 0.2920)$	$r = 0.04$	A very slight significance with a small effect
Total number of university graduates	$-0.2034\ (p = 0.0560)^{**}$	$r = 0.19$	Slightly moderate effect showing that the number of university graduates significantly explains the spatial distribution of spending on higher education
Total number of university professors (full-time and part-time)	$-0.2208\ (p = 0.0190)^{**}$	$r = 0.31$	Moderate effect showing that the number of university professors significantly explains the spatial distribution of spending on higher education

(∗) Significance $p < .1$. (∗∗) Significance $p < .05$. (∗∗∗) Determinations of the size effect's significance were corrected for degrees of freedom.

Source: Self-made

From the information given in Table 2, some conclusions can be derived concerning the spatial dependence of the analyzed variables. The dependent variable trends show slight spatial autocorrelation, but it cannot be concluded that the effect of public spending on higher education is significant. Therefore, it is more logical to conclude that there is no spatial dependence but, rather, that the effect is randomly distributed. All of the independent variables, with the exception of the unemployment rate and the percentage of individuals registered in higher education institutions, show statistically significant spatial autocorrelation. Specifically, the inflation rate and the college-aged population show positive spatial dependence. In contrast, the number of college graduates and university professors display negative spatial autocorrelation.

This analysis reveals that all of the model variables, both dependent and independent, have some spatial dependence, no matter how slight. It is not possible to determine a stable and consistent effect for all cases, but there exists a certain tendency toward significance in the spatial distribution of spending on higher education.

It is important to point out that the statistically significant differences were linked to the effects of the inflation rate, $I_{Moran} = 0.2851 (p = 0.0280)$; the college-aged population, $I_{Moran} = 0.1424 (p = 0.1070)$; the total number of university graduates, $I_{Moran} = -0.2034 (p = 0.0560)$; and the number of university professors, $I_{Moran} = -0.2208 (p = 0.0190)$. The size effects were between $r = 0.12$ and $r = 0.31$, showing an evident statistical effect of spending on higher education.

Finally, and to conclude this first stage of the exploratory analysis, cluster maps were made in which both the dependent and independent variables show specific patterns at the local level.

With respect to spending on university institutions and administrations, several countries stand out. Specifically, Norway, Sweden and Finland stand out for being spatial clusters of high values, i.e., these countries and their

neighbors have significantly higher values than the rest. The case of Latvia and Hungary stands out because these are outliers of values that are higher than their neighbors.

Similarly, it is interesting to analyze the patterns of the different independent variables addressed in this study because all of them are worth commenting on. With regard to the unemployment rate, Portugal is a spatial cluster of high values, i.e., this country and its neighbors exhibit values significantly higher than that expected if the variables were evenly distributed in space. In the case of the inflation rate, Estonia shows a spatial cluster of high values, whereas Switzerland is the exact opposite, being a spatial cluster of low values. With regard to the college-aged population, countries such as France stand out as clusters of high values, whereas Latvia stands out for being the opposite case. Ireland, Belgium, The Netherlands, Denmark, Switzerland and The Czech Republic stand out as spatial outliers of low values. With regard to the percentage of individuals registered in higher education institutions, it is worth mentioning that Norway and Sweden exhibit significantly higher values than those expected if these values were randomly distributed, whereas Switzerland stands out for being the opposite. In addition, Denmark, Belgium and Poland show spatial outlier features of high values with respect to their neighboring countries. Regarding the number of graduates from higher education systems, Spain and The United Kingdom are spatial outliers with high values, whereas Ireland is an outlier with low values. Finally, regarding the number of university professors, The Netherlands stands out as a spatial cluster of high values, whereas France, Denmark, The Czech Republic and The United Kingdom are spatial outliers, with the first three having low values and the last having a high value. It is important to note that, in the analysis of the variables mentioned, both dependent and independent, Iceland is a spatial outlier with low values. In other words, it has significantly lower values than its neighboring countries.

These conclusions, drawn at the local level regarding the significant behavior of the variables, are illustrated in Figure 1.

Starting with this initial analysis of the variables specified in the model (both dependent and independent), it should be highlighted that, at the global level, the variables of inflation, college-aged population, total number of university graduates and number of professors in the university education system show spatial dependence. At the local level, each variable displays spatial autocorrelation. Therefore, it can be affirmed that the aforementioned variables can cause problems in the determination of the OLS parameters of the model; confirmatory analysis thus can be used to indicate whether it is necessary to establish a model with another method that accounts for the effects of spatial dependence.

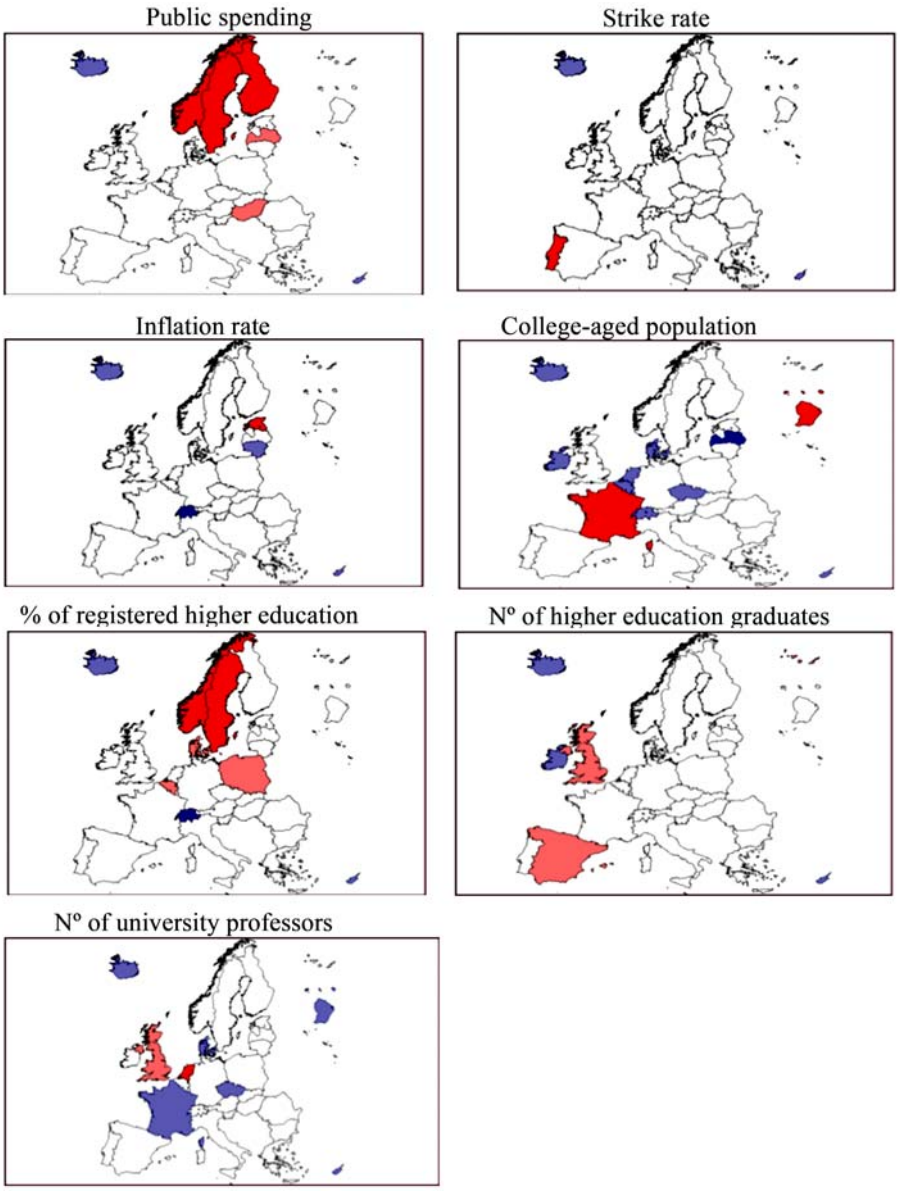

Figure 1. Descriptive maps of the local behavior of the analyzed variables.

White: Not significant. Red: Denotes high values with high significance. Dark blue: Denotes low values with low significance. Lilac: Denotes low values with high significance. Pink: Denotes high values with low significance.

Some relevant comments can be made regarding the data obtained in the determination of the model. Regarding the fit, the percentage of variation explained by the model is 45.36% ($R^2 = 0.4536$). Therefore, it could be said that the prediction capability of the dependent functions given by the independent functions is substantial because they predict nearly half of the variation of the dependent variable (moderate intensity).

Regarding the explicative variables of the model, it is worth noting that four of the six proposed variables are significant.

Specifically, the unemployment rate has a negative relation to public spending on higher education as a percentage of the GDP. One possible explanation for this behavior may be the fact that, if the unemployment rate increases, more resources must be designated for payments and social benefits. Therefore, the higher education budget may correspondingly decrease.

Another independent variable that also significantly describes the variation of the dependent variable is the college-aged population, which has a positive relationship because, as more people have access to the system, spending must increase to guarantee their college studies.

The percentage of registered students is also confirmed as a significant variable that is positively correlated with spending on higher education in the European countries analyzed. It is logical that as more students enroll in the higher education system, more will be spent on it.

Finally, the number of college graduates is a variable that has a negative relationship with the dependent variable because as people graduate and leave the system, it is understandable that the spending associated with their training in the college system will decrease.

The Breusch-Pagan test showed no significant differences when comparing the heteroskedasticity in the errors of the model (different variabilities in the determination of errors of the parameters), with $BP = 5.75$, $df = 6$ and $p = 0.45$. Thus, it can be concluded that the variability of the error terms is constant. Regarding the analysis of the

possible existence of spatial dependence in the model, the value of Moran's I was also not significant $(I = -1.30,\ p = .19)$, which signifies the absence of spatial dependence. Finally, the values of the different Lagrange multipliers were not significant (p_{values} between .12 and .90), which leads to the conclusion that the result of the determination sufficiently fits the original data of the proposed model. Therefore, the OLS values of each parameter were implicitly validated.

5. Conclusions and Future Lines of Research

Based on this study of the dependent and independent variables of the proposed model according to spatial dependence and the parameters of the model, the following can be concluded.

At the global level, the independent variables, including the inflation rate, college-aged population, number of higher education graduates and total number of professors in the system, exhibit spatial dependence patterns. In other words, the trend in one European country is indeed influenced by the trends in neighboring countries. This is an interesting result for promoting unity of the EHEA and for affirming the investment policies of the member countries. It reinforces the idea of interdependence within the whole European Union with regard to higher learning.

The local results affirm that all of the variables analyzed, including the dependent variable, have specific patterns at that level. The most relevant conclusions are presented next.

We should keep in mind that public spending in higher learning is expected in countries such as Norway, Sweden and Finland because they are spatial clusters of high values, i.e., these countries and their neighbors have values that are significantly higher than the rest. The great tradition in Scandinavian countries of making important investments in the educational system is well known (Guisán et al. [7], De Pablos Escobar and Gil Izquierdo [2] and Eicher [3]). The cases of Latvia and Hungary stand out because these are outliers of high values with respect to their neighbors.

With regard to the independent variables specified in the model, for all cases, one or more countries stand out with significantly different patterns relative to the rest. The most relevant conclusions relate to the unemployment rate, in which Portugal is a spatial cluster of high values, with this country and its neighbors possessing significantly higher values than would be expected if the variables were evenly distributed in space. In the case of the inflation rate, Estonia records the highest level, whereas Switzerland is the opposite. Regarding the college-aged population, countries such as France stand out as a cluster of values. With respect to the percentage of individuals registered in higher education institutions, Norway and Sweden stand out, with values that are significantly higher than would be expected in a random distribution situation. Switzerland, however, is again an extreme opposite. For the number of college graduates, Spain and The United Kingdom are spatial outliers with elevated values, whereas Ireland is an outlier with low values. Finally, regarding the number of university professors, The Netherlands stands out as a spatial cluster of elevated values, whereas France, Denmark, The Czech Republic and The United Kingdom are spatial outliers.

The different spatial patterns of each of the variables analyzed reveal the importance of establishing policies for gradually homogenizing the higher learning system in the different member countries.

The usefulness of the spatial statistical technique for analyzing the patterns of different variables at the territorial level, as well as of the proposed model, is also demonstrated in this study.

In addition to the significant results obtained by this research, it must be highlighted that work is still being done along these lines to establish an optimal model in which the predictive values can better explain the variation in the dependent variable. A double analysis is being performed that combines a temporal analysis – synchronous and diachronic – of the existing variables with partial regression models as well as a search for new variables to complete the model. The final goal is to propose and confirm a global spatial model that will better aggregate the effects of each of the variables.

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