REGIONAL CONVERGENCE : AN ANALYSIS OF ITS MAJOR EXPLANATORY FACTORS

ABSTRACT : The main object of this paper is to go further on the specification of what is known as “beta” convergence with the introduction of additional explanatory variables that pick up factors such as transport and communications infrastructure, human capital, R&D and others.

The paper’s methodological interest lies in the estimation of a $\beta$ convergence equation with panel data that consider the introduction of temporary and individual effects. Showing that the relative GDP per capita (p.c.) in the Spanish regions can be considered stationary variables tending to constant specific means (called relative GDPp.c. equilibrium values) and checking the similarity of these series with the observed values in 1993, we conclude that the possibilities of an automatic convergence process are exhausted. The inclusion of the aforementioned variables is oriented toward explaining this result. The reference case to check will be the seventeen Spanish regions in the 1955-1991 period.

Keywords : Convergence, Speed of Convergence, Regional Disparities, Infrastructure, Human Capital, R&D.
1. INTRODUCTION

The controversy about the possible evolution of the economic regional disparities has a long tradition. Very confronted positions lived together in the 50s and 60s, going from the neoclassical explanation to radical critics, and through the thesis of the accumulative causation as well as through the centre-periphery one.

In the 70s this debate was driven out to a second ground by the economic crisis. First, because macroeconomic and sectorial problems became the most considered ones, either to policymakers or to analysers and academicians. And second, because the very impact of the crisis widened substantially the number of “problematic regions”, which not only included the less developed ones, but also a great number of those regions considered industrialized and/or wealthier and more dynamic in a previous phase.

Since the second half of the eighties, the concern about economic growth and its causes has occupied an outstanding position within the economic analysis, together with the overcoming, at least in part, of the most relevant concerns of the previous stage. The attention paid to problems and limitations from the supply side and the renewed resort to neoclassical explanations are the root of this new wave. This has launched an important and well-known group of contributions that have carried out the debate between convergence supporters and non-convergence ones, either in national economies or at a regional level.

This paper is in line with the authors’ previous works on regional convergence in Spain (see: Raymond, J.L. and García-Greciano, B., 1994; Raymond, J.L., 1995; Cuadrado J.R. and García-Greciano, B., 1995a y 1995b) but from a different focus. This analysis takes as basic reference the relative GDP per capita equilibrium values in the different Spanish regions, which is derived from an amplified beta convergence equation and contrasts the relationship of these equilibrium values with some macrovariables, such as the effort in terms of human capital improvement, in R&D, or regional infrastructures, which are to be understood as significant when talking about regional growth.
2. THE SIGMA CONVERGENCE EVOLUTION

Regional disparities in Spain have shown a trend of reduction along the time and of stagnation in recent years. Several papers have remarked this fact from an empirical perspective using different dispersion indexes. (See: Cuadrado, 1988; Mas et al. 1993; or Raymond and García Greciano, 1994, among others). In modern literature the reduction of inequalities among economies has been generally called sigma convergence (see: Barro and Sala-i-Martín, 1991). In order to remember synthetically the evolution of regional inequalities in Spain, the sigma convergence has been updated to 1995 and calculated using the following expression:

\[
\sigma_t = \left[ \frac{\sum_{i=1}^{17} (\ln GDPpc_i - \ln GDPpc_t)^2}{17} \right]^{1/2}
\]

where “\(\ln GDPpc_i\)” is the logarithm of the GDP per capita of the autonomous community (or region) “i” in the year “t”, “\(\ln GDPpc_t\)” is the logarithm of the Spanish GDP per capita, which is equivalent to a weighted mean of the regional GDPs per capita, and “17” is the number of autonomous communities (regions) except for the cities of Ceuta and Melilla. The data source used is the “Renta Nacional de España y su Distribución Provincial” of Banco Bilbao-Vizcaya (BBV), available biennial or triennial from 1955 to 1991, and for 1992, 1993, 1994 and 1995 the estimations of FIES Foundation with the same methodology. This statistical source has been selected because of its great historical covering, main aspect for this type of analysis, and which is not provided by other sources like the Regional Accounts officially produced by the Spanish Statistical Institute from 1980.

The results of this calculation are represented in Figure 1, which confirms the two known trends of the regional sigma convergence evolution. The first stage, from 1955 to 1979, is a convergence phase in which the disparities among autonomous communities are reduced considerably. However, in the second stage, from 1981 to 1995, stagnation appears in the convergence process without showing symptoms of new advances.
The question resulting of this change of trend could be referred to the factors which have favoured the convergence in this first stage and to those ones which have impede new advances in a second phase.

**FIGURE 1**

SIGMA CONVERGENCE (Log. GDP per capita)

While convergence is predictable by the neoclassical growth models, new visions stress the remaining or even increasing inequalities between economic spaces. In the first case, the advantage of being “poor” together with the factors mobility would explain the equalization of income per capita levels. In the second one, the advantages of being “rich” as a factor to impulse growth is stood out. If both of these facts act simultaneously, phases of convergence and stagnation in the convergence processes, or even in the divergence ones, could be found.

Additionally to utilize *sigma* convergence, in order to measure if there is a tendency towards an approach of the GDP per capita levels among different economic spaces, the literature has introduced the concept of *beta* convergence, which is a way to evaluate whether regions with an initial lower GDP per capita would show a trend to a higher growth than initially rich ones.
Beta convergence is generally calculated for a period of years and occasionally the conclusions become contradictory. In this paper, by the introduction of a new definition of the beta convergence model, an estimation of this type of convergence is presented, which takes into account a shortening phase in the distances among the Spanish regions (1955-1979), as well as a breaking phase in this process from 1979.

3. Relative GDP per capita equilibrium values and conditioning factors

The concept of relative GDP per capita equilibrium values of the Spanish regions, introduced in this section, is a statistical concept. The idea is that the relative levels of GDP per capita in each Spanish region with respect to the mean, can be considered as stationary variables tending to constant specific means. The convergence stops when this level has been reached. Thus, the differences of income per capita tend to prevail.

First, we are going to define the convergence model that presuppose stationarity in the GDP per capita of the Spanish regions. Second, the levels of the relative GDP per capita equilibrium values of the Spanish regions are calculated and compared to the observed values for 1993, getting the similarity between these magnitudes and concluding that the possibilities of an automatic convergence process seem to be run out. Finally, the existing relationship between the relative GDP per capita equilibrium values of the Spanish regions and some of their potential explanatory factors which have been stood out in the literature is explored.

3.1. The beta convergence equation

We propose the following beta convergence equation:

\[ \Delta \ln Y_{it} = \alpha_i - \beta \ln Y_{i,t-1} + \gamma_t + \varepsilon_{it} \]  

(2)

where \( \Delta \ln Y_{it} \) is the interannual GDP per capita growth of the region “i” in the year “t”, \( \alpha_i \) are the specific individual effects, \( \ln Y_{i,t-1} \) is the GDP per capita of the previous year, \( \gamma_t \) are the specific temporary effects and \( \varepsilon_{it} \) is the random variable, which contains the influence of the
remaining omitted variables. This is a beta convergence equation because it is supposed, ceteris paribus, that the higher the initial income is, the lower the growth is.

This equation, proposed by Raymond (1995), introduces two basic differences with respect to the common beta convergence equations:

1) First, the introduction of specific temporary effects “γ_t” implies no stationarity in the GDP levels and permits the estimation of the model using panel data.

2) Second, the introduction of specific individual effects, that are very significant statistically, permits the definition of relative GDP per capita equilibrium values, that are different for each region.

Doing a weighted average of equation (2) for the seventeen Spanish regions, we obtain the growth at a national level:

\[ \Delta \ln Y_t = \bar{\alpha} - \beta \ln Y_{t-1} + \gamma_t + \epsilon_t \]  

(3)

Finally, the equation to estimate derives from the difference between (2) and (3):

\[ \Delta \ln Y_{it} - \Delta \ln Y_t = (\alpha_i - \bar{\alpha}) - \beta (\ln Y_{i,t-1} - \ln Y_{t-1}) + \epsilon_{it}^* \]  

(4)

where “(\alpha_i - \bar{\alpha})” measures the autonomous differential growth at a regional level and 
\[ \epsilon_{it}^* = \epsilon_{it} - \bar{\epsilon}_t \]  
is the random variable.

Table 1 shows the results of the equation estimated, using a panel data consisting of the seventeen Spanish regions for the 1955-1991 period. Due to the lack of information with one year periodicity, these data are generally biennial, except for two couple of years. On the other hand, the dependent variable is the annual growth.


<table>
<thead>
<tr>
<th>Independent variables:</th>
<th>Coefficient</th>
<th>t - statistic</th>
<th>Coefficient</th>
<th>t - statistic</th>
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<tr>
<td>$\ln Y_{t-1} - \ln Y_{t-1}$</td>
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<td>5.522</td>
<td>0.022</td>
<td>4.649</td>
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<tr>
<td>Constant for Andalucía</td>
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<td>-4.033</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Constant for Aragón</td>
<td>0.006</td>
<td>1.278</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Constant for Asturias</td>
<td>-0.005</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Constant for Baleares</td>
<td>0.027</td>
<td>4.439</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Constant for Canarias</td>
<td>-0.006</td>
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<td>Constant for Cantabria</td>
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<td>-0.191</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Constant for Cast.-La Mancha</td>
<td>-0.018</td>
<td>-2.672</td>
<td>-</td>
<td>-</td>
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<td>Constant for Cast.-León</td>
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<td>-</td>
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<td>Constant for Cataluña</td>
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<td>2.869</td>
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<tr>
<td>Constant for C. Valenciana</td>
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<td>Constant for Extremadura</td>
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<td>Constant for Navarra</td>
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<td>1.981</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Constant for País Vasco</td>
<td>0.011</td>
<td>1.651</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Constant for Rioja, La</td>
<td>0.005</td>
<td>1.087</td>
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<td>-</td>
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<tr>
<td>Coefficient of Determination</td>
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<td>Standard Error</td>
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<tr>
<td>Sum of Squared Resid</td>
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<tr>
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<tr>
<td>N. of observations</td>
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<td>289</td>
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</table>

In the same table we observe that the beta coefficient, according to the common statistics, is significantly different from zero. A beta coefficient significantly different from zero implies the stationarity of the relative values of the regional GDP per capita. The distribution of the corresponding statistic in the null hypothesis contrast, does not follow the “t” standard distribution. In any case, an estimated coefficient of 5.5 times its standard error could be interpreted as an evidence against the null hypothesis.
Additionally, conditioning to the stationarity of the variables, the individual specific effects are significant. A test of whole significance using the “Chi-squared” statistic, rejects the null hypothesis at a significance level lower than 1 per100.

3.2 Definition of relative GDP per capita equilibrium values

The estimated convergence equation can justify a convergence process when the regional differences in income per capita are very high, but leads to a sigma convergence degree which tends to be stable when the higher regional divergences of income have been eliminated. The insight is that certain interregional differences of income could be everlasting, since, given a certain degree of convergence, the expected growth of the regional income is the same in all regions.

In fact, the relative GDP per capita equilibrium values of the various Spanish regions, according to Raymond (1995), can be calculated from equation (4). These values are obtained by taking the expected values and making equal the expected value of the difference of income between region “i” with respect to the mean in the period “t” and in the period “t-1”. That is:

\[ E(\ln Y_{it} - \ln \bar{Y}_i) = (\alpha_i - \bar{\alpha}) + (1 - \beta)E(\ln Y_{it-1} - \ln \bar{Y}_{i-1}) \]  

\[ \text{if} \]
\[ E(\ln Y_{it} - \ln \bar{Y}_i) = E(\ln Y_{it-1} - \ln \bar{Y}_{i-1}) = y_i^* \]

where “\( y_i^* \)” should be interpreted as the relatvie GDP per capita equilibrium values for the region “i”. That yields:

Relative GDP per capita equilibrium value of region i, "\( y_i^* \)" = \( \frac{\alpha_i - \bar{\alpha}}{\beta} \)

When this value is reached, the expected growth of the regional GDP per capita equals the expected growth of the GDP at a national level. For less developed regions, this equilibrium value is reached when distances have been reduced. The same reasoning can be applied to the most developed regions that once they have shortened distances, their relative prosperity do not impede an expected growth equal to the mean.
Figure 2 reflects the results of this calculation. Comparing the observed and forecasted relative GDP per capita values, we notice that the points are located close to the bisectrix, reflecting an exhaustion of the possibilities of convergence in 1993.

**FIGURE 2**

**RELATIVE GDP PER CAPITA:**

**EQUILIBRIUM VALUES versus OBSERVED VALUES**

3.3 Some explanatory factors and their relationship with the relative GDP per capita equilibrium values

The definition of the relative GDP per capita equilibrium values is a statistical concept. It informs to which values tend the relative GDP per capita values referred to the Spanish regions when the historical series evolution is taken into account. However, a purely statistical relationship should not be identified with a historical fatalism. These relative GDP values are likely to be related to certain macrovariables and a feedback process is also likely to exist. Thus, the relative GDP per capita values could possibly be influenced by human capital,
infrastructure and R&D expenses, as well as a higher relative income level should lead to higher education, infrastructure and R&D expenses. According to the economic theory, the existence of a positive association among these variables suggests a process of bidirectional causation.

The aim of the following figures is to illustrate this idea, without giving a structural interpretation to the estimated slopes due, precisely, to the possible bidirectional causation, formerly mentioned, or to the consequence that the efficiency of expenses in infrastructures, human capital and R&D depend on the rationality of such expenses are performed.

**Transport infrastructure**

The transport infrastructure is one of the basic factors, when trying to boost less developed areas, and therefore, it contributes to economic growth. A widely used argument justifies that a good transport net boosts commercial flows, as well as economic factors flows, having an influence on the income levels in the long term. However, the development of transport infrastructure is also linked to the demand of the infrastructure, in quality and quantity terms, that usually is higher in the most prosperous areas.

The relative transport indicator is based on an estimation of the physical transport infrastructures by regions, for 1989, including highways, first and second class roads, railway, ports and aeroports. To calculate this indicator, the values in physical terms were weighted by the area of each region (source: Delgado, M.J., 1995). Later, the relative value with respect to the national mean was calculated.

Figure number 3 shows the relationship between the relative transport infrastructure indicators and the relative GDP per capita equilibrium values, showing a positive correlation (0.71). At the same time, regions with a higher relative GDP per capita equilibrium values own a higher infrastructure endowment, in relative terms, than those ones with lower equilibrium values.
Communication infrastructure

Communication infrastructure is also an important factor for development and therefore, it is necessary to take it into account. The relative endowment indicator used here includes, for 1989, a series of components: lines of installed telephones, postal service, telephone system and data transmission networks, all of them weighted by area and relativized afterwards (source: Delgado M.J. 1995).

Figure number 4 shows the results obtained by linking this relative endowment indicators with the relative regional GDP per capita equilibrium values. A positive correlation between the equilibrium values and the communication indicator can also be seen. The quadrant with a higher endowment contains the four regions having high relative equilibrium values, like Baleares, Cataluña, Madrid and País Vasco; although some others with also high equilibrium
values, show a lower endowment like Navarra, Rioja or Aragón. Likewise, regions with lower relative GDP per capita equilibrium values are characterized by their lower infrastructures communication endowment. Finally, the higher dispersion observed when linking these two variables, could be explained by the fact that this type of infrastructures is essentially of a net-type.

**FIGURE 4**

RELATIVE GDPpc EQUILIBRIUM VALUES AND RELATIVE COMMUNICATION INDICATOR

Human capital indicator

While the physical capital endowment has been considered during a long time one of the most important inputs of the economic growth, the more recent literature stands out the human capital as a basic factor in which an investment effort should be carried out. Due to the problems to evaluate a human capital indicator, we have considered the education expenses as a proxy variable in this paper (source: Palafox et al., 1995). The impossibility to obtain an adecuated regional public expense in education for the seventeen Spanish regions, has lead us
to consider only the private expense in education. The indicator was obtained weighting the private expenses per inhabitant and later on it was calculated in relative terms with respect to the mean.

Figure 5 represents the relationship between the private relative expenses in education and the relative GDP per capita equilibrium values, showing a clear positive association. This type of association shows again the feasible bidirectional causation. The recent literature stands out the human capital as one of the most differentiating sources of growth in our economies and at the same time we observe that the wealthiest regions own the higher education expenses. Consequently, it can be observed not only that the regions with a higher relative GDP per capita value spend more in education, as it could have been expected, but also that all of them own a relative education level (synthetic index) higher than the mean. However, this fact shows exceptions and the results for 1989 were not so significant when using a synthetic education index by regions (source: Delgado, M.J., 1995\(^1\)). The synthetic education indicator is relatively high in some regions with lower GDP values, like Castilla-León or Castilla-La Mancha, whereas the private expense in education is relatively low.

**FIGURE 5**

**RELATIVE GDPpc EQUILIBRIUM VALUES AND RELATIVE EDUCATION INDICATOR**
A possible indicator of the innovative effort of an economy is its R&D expense, accepting that it is directly linked to the development in the field of research and its applications, and even with the introduction of external innovations in the observed country (region).

Figure 6 offers the results of the relationship between the relative GDP per capita equilibrium values and the R&D expense of the seventeen Spanish regions, weighted by the population and in relative terms. Although the correlation coefficient is not very high, the association is clearly positive.

**FIGURE 6**  
RELATIVE GDPpc EQUILIBRIUM VALUES AND RELATIVE R&D INDICATOR

From this figure we can deduce that regions with a higher R&D expense own the higher income per capita equilibrium values except for Baleares, which is represented in this relationship as an atypical case, because it is a clearly turistic region. On the other hand, regions with lower R&D expenses have lower GDP per capita equilibrium values. Furthermore, wealthier regions are thought reasonable to concentrate a higher R&D investment, due to the better
communication indicator shown by these regions among other factors. A feedback process appears clearly, as well as a certain accumulative effect with respect to other indicators.

Testing other indicators

The possible relationships among the regional relative GDP values and specific significant indicators may be quite more numerous. At least, there are more relationships than those ones formerly exposed. The higher or lower energy availability, the existence of agglomeration economies in some areas but not in other ones, as well as available health services and even more qualitative factors, could influence the better or the worse behaviour of a regional economy.

The analysis carried out with respect to these three first indicated factors have provided us with hardly acceptable results in our case. Regional indicators of available energy infrastructure were used as an energy indicator. This included the electric network and oil and gas pipelines. However, the result showed a wide dispersion.

A health infrastructure indicator based on available beds in sanitary establishments and on available medical and infirmary services with respect to the population were used to make a health infrastructure indicator. In this case, the obtained correlation was not significant either.

Finally, and due to the impossibility of an accurate measurement of agglomeration economies, some tests were carried out by using a possible proxy indicator, based on the volume of population located in big urban centres in all regions\(^2\), weighted by its corresponding education indicator. We can not consider this results of great interest, although researches referred to other countries have supplied quite acceptable data.
4. CONCLUSIONS

The carried out analysis does not lead to conclusions “sensu stricto”, but it sets up some interesting ideas about the regional convergence in Spain and at the same time opens new horizons to explore.

First, the carried out sigma convergence estimation shows very clearly the existence of two stages. In the first one, 1955-1979, the economic regional disparities were slightly reduced. In the second one, 1979-1985, the convergence is interrupted and no symptoms of possible changes seem to appear. We could explore possible explanations to this fact starting from that information.

The beta convergence analysis permits to evaluate if regions with lower initial GDP per capita values show a trend to a higher growth than those initially wealthier regions. In our case, we have used an amplified beta convergence equation by including temporary and specific individual effects, in contrast with the usual equations accepted by the literature.

The attained results show that interregional differences in GDP per capita can be characterized as stationary variables which tend to specific means (called relative GDP per capita equilibrium values in this paper) which practically coincide with the observed values in 1993. This can be interpreted as a maintenance of the regional disparities after having smoothed the outstanding income differences.

The search of the possible factors which could produce this stagnation in the convergence process has lead us to take into account some variables, which could be correlated with the relative GDP per capita equilibrium levels, outstanding a possible feedback effect. The analysis carried out offer significant results in the case of transport and communications infrastructures, and education and R&D expenses. However, it is convenient not to forget the possible bidirectional causation. That is, if these variables do have a clear influence in the determination of GDP per capita equilibrium values, a higher relative income level produces usually in its turn a higher expenditure in infrastructures, education or/and R&D. In conclusion, the positive association between these variables is usually bidirectional and could contribute to the permanence of regional disparities.
NOTES

1. Calculated taking into account the number of students in each education stage (primary, secondary, professional and university), putting in connection the weighted indicator with the corresponding population and, in the case of university studies, with its higher cost by post.

2. Towns with more than 100,000 inh. were taken as limit first, whereas those ones of more than 500,000 inhabitants were considered in a second test.

REFERENCES


