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PUBLIC CAPITAL, PRODUCTIVE EFFICIENCY AND CONVERGENCE IN THE SPANISH REGIONS (1964–93)

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This paper analyses the behaviour of productive efficiency in the Spanish regions for the period 1964–93. From a growth accounting approach, it describes the regional evolution of total factor productivity (TFP^s), based on a private inputs production function. A stricter measure of efficiency is then quantified, which is not equivalent to Solow's residual, since public capital is included in the production function and constant returns to scale are not imposed. Finally, on the basis of the measures of total factor productivity and efficiency, the study discusses the existence of technological convergence among Spanish regions and the role played in it by public capital.

The renewed interest in the analysis of the process of growth reflected in economic literature in recent years has also occurred in the case of the Spanish economy, with some peculiarities which are worth mentioning. In the 1980s, two important institutional changes took place: a profound political and administrative decentralization, the regions now being autonomous in many decisions on public expenditure, and the incorporation of Spain into the European Community, which as it is well known has a powerful regional policy. Both changes have meant that the analysis of regional economies, and especially their growth paths, have received much more attention from politicians and economists, and even from the population in general. In particular, intense discussion has taken place regarding the effects of development policies and on criteria for geographical distribution of infrastructures. In both cases, much attention has been paid to discussing their capacity to contribute to convergence among the different regions.

As a consequence of this greater interest in the analysis of growth from a regional perspective, efforts have also been made to improve the relevant statistical information. In particular, statistical series have been drawn up for investment and accumulated capital stock in each region, both private and public.[1] This information, only recently available and the first of its kind, as far as we know, in the European regions, substantially broadens the possibilities of research into the Spanish case in this field, where before not even the simplest exercises in growth accounting could be attempted. Furthermore, since the series now available allow the time dimension of growth analysis to be combined with the regional dimension, it is possible to work with a panel of data and apply the corresponding techniques.

This article analyses the growth of the Spanish economy over the period 1964–93, during which it can be observed that the per capita income levels of the Spanish regions converged. The objective of the study is to evaluate this process of convergence in income from the perspective of the productive efficiency of the regions, in three different ways. First, Section I considers the importance of the contributions of the private factors of production and of improvements in total factor productivity to the growth of output. Secondly, section II studies the existing relationship between the standard measure of efficiency (Solow's residual or TFP^s) and a stricter measure when the endowments of public capital are considered. Section III analyses whether or not the convergence in per capita income

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[1]Appendix 1 contains a brief summary on the capital stock series estimates.

observed among Spanish regions is the result of a process of convergence in efficiency in the strict sense. Finally, Section IV concludes.

I. Growth and Total Factor Productivity in the Spanish Regions

The habitually-used measure of productive efficiency has its origin in Solow's (1957) well-known contribution, according to which the growth rate of output can be decomposed into three components: the contribution of the factors of production (capital and labour) and a residual, habitually called total factor productivity TFP^s.[2] It can also be shown that it is possible to express the levels of TFP^s of a region "i" at time "t" in relation to the efficiency of a "base" region in a "base" year. In the estimates presented, Spain has been considered the "base" region and the initial year, 1964, as the base year.

Figure 1 shows the TFP^s levels corresponding to the initial (1964) and the final (1993) year computed according to expression (A.4) in Appendix 2. The conclusions that can be derived from this figure are as follows:

(a) There exist notable differences in the TFP^s levels among regions. In the last year considered, 1993, Madrid, the Basque Country, La Rioja and Navarra, in the north, the Mediterranean regions (Catalonia and C. Valenciana), and the islands (the Balearics and Canaries) appear in the first positions in terms of productivity. In contrast, the two Castilles, Extremadura, Murcia and the regions of the northwest of Spain (Galicia, Asturias and Cantabria), are the least productive.

(b) In the 29 years analysed, there have been important changes in the efficiency levels that will be analysed in Section III. If we consider the initial situation, it can be observed that Madrid, Catalonia and the Balearics are also the most productive, the regions of Galicia and Extremadura being the least efficient according to this measure.

Table 1 shows the growth rates for output (Gross Value Added, GVA) and for the two sources of growth (inputs and TFP^s), computed according to (A.3) in Appendix 2, for the period 1964–93 for the 17 regions of Spain. In it can be observed that:

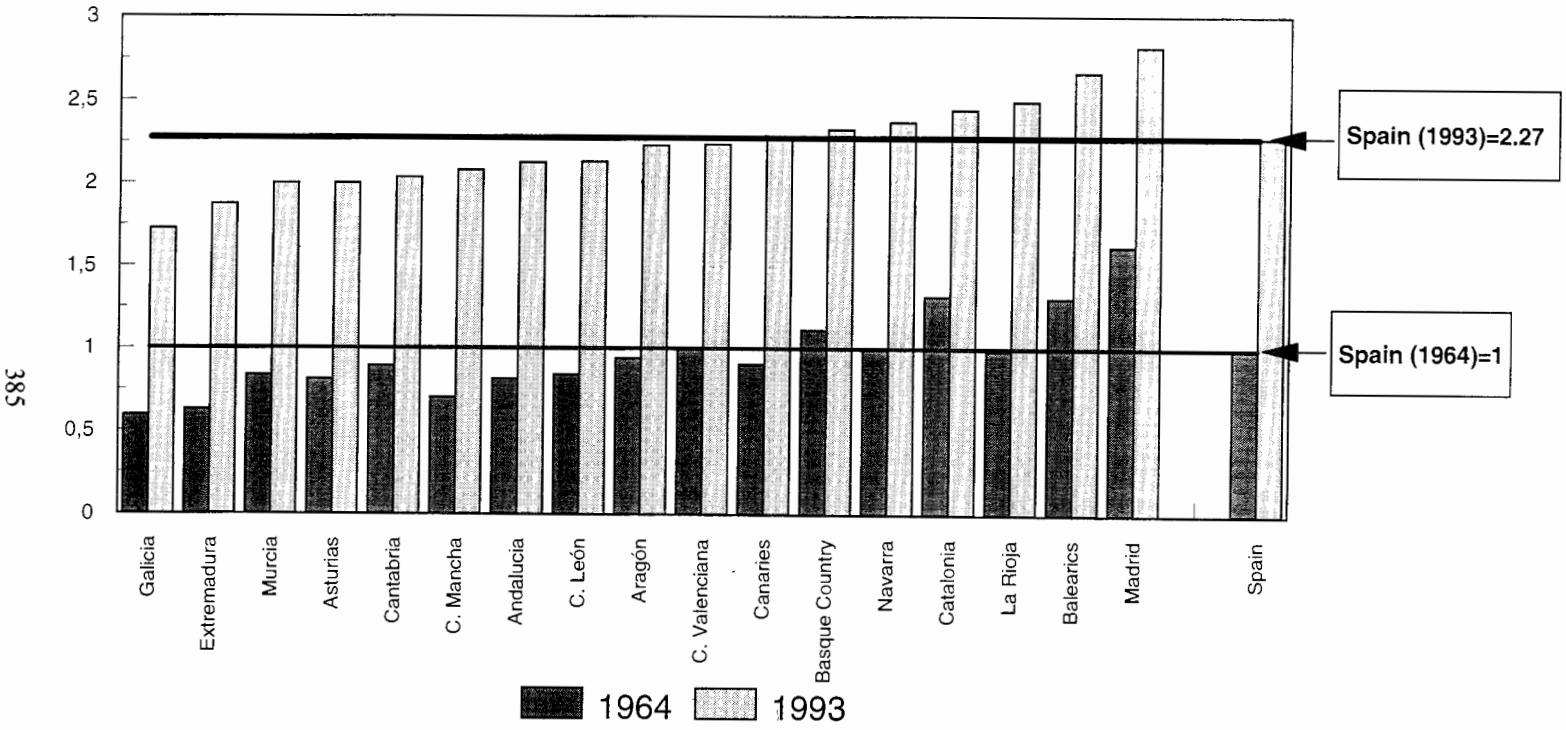
(a) The growth rate of GVA at the national level (3.66 percent p.a.) was the result of a positive contribution by capital (1.15 percent) and by TFP^s (2.83 percent).[3] The labour factor contributed negatively to growth (−0.32 percent) as employment decreased.[4]

(b) This behaviour is common to practically all the regions of Spain, but not all experienced negative growth rates in employment (the growth rate of labour is positive in the Balearics, the Canaries, Catalonia,

[2]Appendix 2 describes the procedure used in the estimation of the results presented in Figure 1 and Table 1.

[3]It is possible that such an important positive contribution of capital is biased upwards by the procedure adopted in the estimation of capital stock. The series of private capital implicitly assume constant depreciation rates without taking into account, therefore, the phenomenon of "scrapping" associated with the intense structural change of the 1960s and with the heavy economic recession and industrial reconversion undergone by the Spanish economy in the 1970s and 1980s.

[4]It is worth mentioning that the negative growth in aggregate employment affects the private sector. Total employment experienced slightly positive growth rates in these years, thanks to the growth of employment in the public sector.



Source: See text.

Figure 1. TFP^s levels in the Spanish Regions (TFP^s Spain (1964) = 1.0)

Madrid, Murcia and C. Valenciana). At the same time, there was a generalized process of capitalization, of high intensity.

(c) The growth rate in TFP^s has contributed positively to the growth of output in all regions ranging from 4.23 percent p.a. in Extremadura to 1.75 percent p.a. in Madrid. On average, TFP^s explains 77 percent of the production growth.

TABLE 1

SOURCES OF REGIONAL GROWTH 1964–93
(ANNUAL GROWTH RATES, %)

	$\dot{GVA}$	$s\dot{IL}$	$sk\dot{K}$	$\dot{TFP}^s$
Andalucia	3.69	−0.80	0.93	3.56
Aragón	3.41	−0.66	1.07	3.00
Asturias	3.06	−0.76	0.98	2.84
Balearics	4.24	0.32	1.54	2.39
Canaries	5.22	0.28	1.68	3.25
Cantabria	2.50	−0.74	0.68	2.56
C. Mancha	3.82	−1.09	0.89	4.01
C. León	3.08	−1.13	0.86	3.35
Catalonia	3.40	0.18	1.31	1.92
Extremadura	3.13	−1.63	0.53	4.23
Galicia	3.95	−0.88	0.92	3.91
La Rioja	4.03	−0.39	1.04	3.38
Madrid	3.92	0.49	1.67	1.75
Murcia	4.64	0.20	1.15	3.29
Navarra	3.81	−0.24	1.12	2.93
Basque Country	2.71	−0.28	0.75	2.24
C. Valenciana	4.23	0.06	1.32	2.85
SPAIN	3.66	−0.32	1.15	2.83

[a]Source: BBV and Foundation BBV/IVIE (1996).
[b]Notes: See annex.

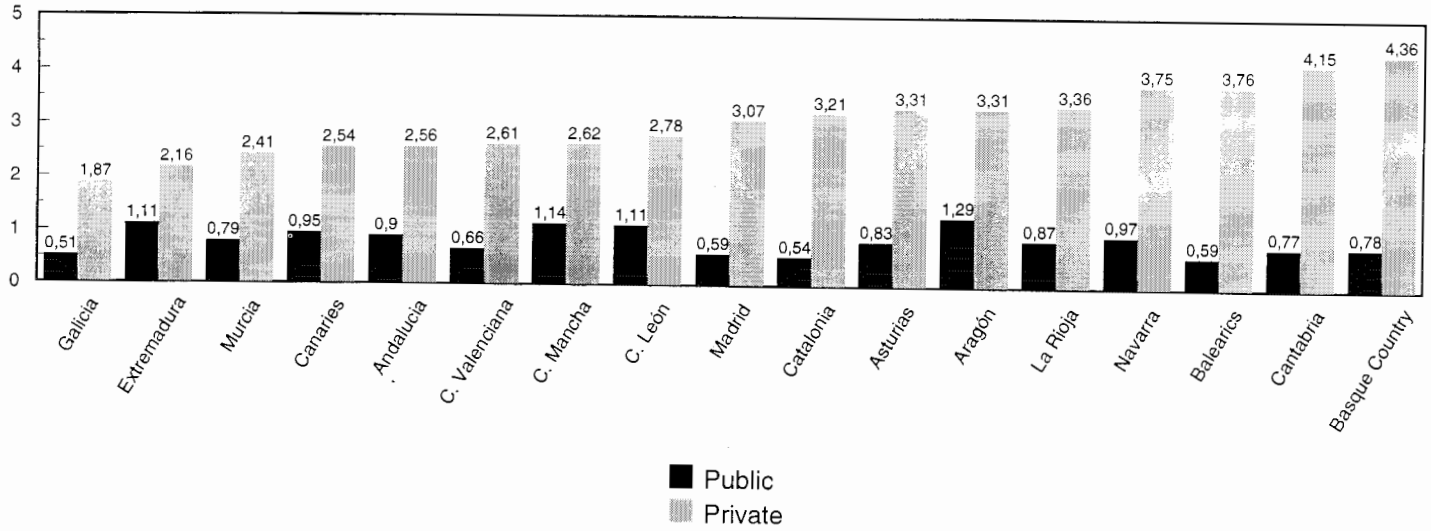
To sum up, the process of growth of the Spanish economy has been dominated by an intense process of capital accumulation accompanied by practical stagnation of employment levels. In fact, the private capital-labour ratio multiplied by four in the period 1964–93, although there are substantial inequalities among regions in both private and public capital-labour ratios (Figure 2). As a result, the gains experienced by labour productivity have been the result of strong growth in TFP^s and of more modest growth in the capital/labour ratio.

II. PUBLIC CAPITAL AND TOTAL FACTOR PRODUCTIVITY

The preceding section considered the standard version of growth accounting. This section expands those results in two directions: (a) modifying the production function (A.1) in Appendix 2 by introducing public capital as an additional factor of production and (b) not imposing restrictions on the type of returns to scale in the production function.

The explicit consideration of public capital (G), as proposed in the specification of the production function made by Aschauer (1989), transforms the standard production function into:

$$y_{it} = A_{it} F(K_{it}, L_{it}, G_{it}). \quad (1)$$



Source: BBV and Foundation BBV/IVIE (1996).

Private sector excluded energy and residential capital. See text for details.

Figure 2. Private and public capital/labour (millions of constant pesetas (1990) per worker) Average 1964–93

From (1) and deriving with respect to time,

$$\dot{y}_{it} = \dot{A}_{it} + \varepsilon_{L,it}\dot{L}_{it} + \varepsilon_{K,it}\dot{K}_{it} + \varepsilon_{G,it}\dot{G}_{it} \tag{2}$$

where $\varepsilon_{L,it}$, $\varepsilon_{K,it}$, $\varepsilon_{G,it}$ are the elasticities of output with respect to labour (L), private capital (K) and public capital (G), respectively. If we do not impose any restriction on the type of returns to scale and if we assume, following Hulten and Schwab (1993), that labour receives an income share according to its marginal productivity, that is, if we assume that $\varepsilon_{L,it} = s_{L,it}$, expression (2) can be written as

$$\dot{A}_{it} = \dot{y}_{it} - s_{L,it}\dot{L} - s_{K,it}\dot{K} + (1-\rho_{it})\dot{K}_{it} - \varepsilon_{G,it}\dot{G} \Rightarrow \dot{TFP}^s = \dot{A}_{it} + (\rho_{it}-1)\dot{K}_{it} + \varepsilon_{G,it}\dot{G} \tag{3}$$

where $\rho_{it} = \varepsilon_{L,it} + \varepsilon_{K,it}$ indicates the type of returns to scale in private inputs implicit in the production function.

If we assume that ρ and ε_G are constant over time and equal across regions, and integrating (3) over time, we obtain

$$\ln(TFP^s_{it}) = \ln A_{it} + (\rho - 1)\ln K_{it} + \varepsilon_G \ln G_{it}. \tag{4}$$

If we further assume that disembodied technical progress grows at a rate λ_i, thus allowing the possibility of different growth rates in the efficiency term and therefore the possibility of analysing the existence of convergence in efficiency among regions[5]

$$\ln A_{it} = \ln A_{i0} + \lambda_i t \tag{5}$$

expression (4) becomes

$$\ln (TFP^s_{it}) = \ln A_{i0} + \lambda_i t + (\rho - 1)\ln K_{it} + \varepsilon_G \ln G_{it}. \tag{6}$$

Equation (6) indicates that the level of TFP^s is determined by four elements: (a) the initial level of efficiency, A_{i0}; (b) the exogenous growth rate of technical progress (λ_1); (c) the contribution of public capital, with elasticity ε_G; and (d) a term which reflects the discrepancies with respect to the case of constant returns to scale ($\rho - 1$).[6] This equation will be the point of reference in the estimations presented below.

[5]It would be less restrictive in the estimation to allow the variation among regions not only of λ and A_{i0} but also the elasticity of public capital, ε_G, and the type of returns to scale, ρ. However, in this case the number of parameters to be estimated would be 17×4 (68). It must be taken into account that we have available a total of 255 observations (17×5) since the BBV (source used for the variables GVA, employment, and income shares) only supplies information every two years. For this reason, it is hard to estimate any particular parameter precisely and to interpret the resulting coefficients.

[6]Hulten and Schwab (1993) consider a further way in which public capital may affect output. As well as considering it as a productive input, they propose including it also in the term of efficiency A, as an environmental or spillover factor which increases the productivity of the inputs. Its equivalent expression to (5) takes the form:

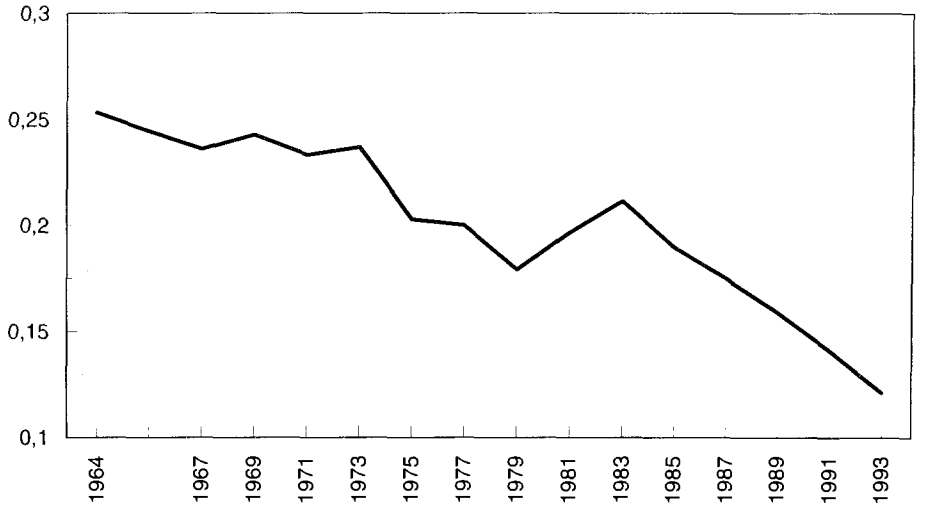
$$\ln A_{it} = \ln A_{i0} + \lambda_i t + \sigma \ln G_{it}. \tag{5 bis}$$

However, if (5 bis) is substituted in (4), it is not possible to identify the influence of public capital through each of the two channels indicated. For this reason, if these two forms of influence of public capital are accepted, the coefficient affecting G in the estimation of Table 2 would then be equal to $(\varepsilon_G + \sigma)$ and not only ε_G which is the interpretation given in the text.

In the case we are analysing, it is interesting to verify if there are particular circumstances which influence the productive results of each region (e.g. composition of output, location, use of technology, climatic conditions, etc.) and which are not reflected by the explanatory variables. In order to detect these effects, equation (6) has been estimated with a panel of data for the Spanish regions in the period 1964–93, using the within-group or fixed-effect estimator. In this case, the value of the fixed effects can be identified with the initial situation of the efficiency parameter for each region ($\ln A_{i0}$), estimated as a constant. The results of the estimation appear in the following section.

III. Convergence in Efficiency

The reduction of inequalities in technological efficiency among regions may be approached in two alternative ways: (1) on the basis of statistics of dispersion; (2) by analyzing whether those regions which start with lower efficiency levels experienced higher growth rates in this variable.[7]



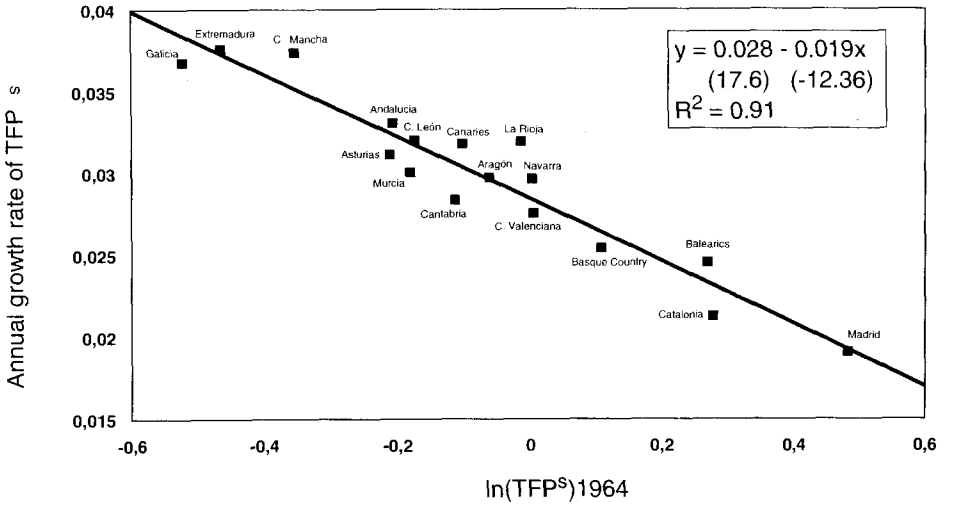
Source: See text.

Figure 3. Sigma convergence in TFP^s (standard deviation of ln)

Using the standard deviation of ln (TFP^s) as a measure of dispersion, Figure 3 shows a sustained decrease until 1979, an increase in the period 1979–83, and a continuous decrease until 1993. We can, therefore, speak of a reduction of the disparities in TFP^s in the period under analysis.

Figure 4 illustrates the second concept of convergence (β-convergence). It shows that there is a negative relationship between the annual growth rate of TFP^s and the level of TFP^s in 1964, being statistically significant ($\beta = -0.019$, with

[7]This is the transposition to *TFP* of the concept of σ and β-convergence popularized by Barro and Sala-i-Martin. See, for example, Barro and Sala-i-Martin (1991 and 1992). See also Baumol, Nelson and Wolff (1994) for a review of alternative concepts of convergence.



Source: See text. t-statistic in parentheses.

Figure 4. Beta convergence of TFP^s (1964–93)

a t-statistic of -12.36) so that it is possible to affirm the existence of convergence in efficiency.

The presence of convergence in the most-used indicator of efficiency, TFP^s, poses the question of whether this is due to defects in the capacity of the indicator itself to capture the level of effectivity reached in the use of factors. In particular, the analysis developed in Section II on the role of public capital in the gains registered in TFP^s suggests that A_t would be a better measure of efficiency in the strict sense.

However, it is not possible to extend growth accounting to calculate a series of A_{it} by eliminating the effect of $\varepsilon_G \ln G$ [see expression (6)], as to evaluate the impact of G it was necessary to resort to estimations. Therefore, in order to explore convergence in (A_{it}) it is necessary to allow λ_i to vary from one region to another. For this purpose, we estimate equation (6), the results of which appear in Table 2. This table shows the results of the estimation, imposing the assumption of constant returns to scale in private inputs since it is not possible to reject this hypothesis [the parameter $(\rho - 1) = 0.0432$ is not statistically significant (t-student $= 0.6576$)].

The results presented in Table 2 shows the importance of endowments of public capital in the explanation of the TFP^s of the Spanish regions ($\varepsilon_G = 0.1107$ with a t-statistic of 2.078). This elasticity is similar to the one obtained in Mas, Maudos, Pérez and Uriel (1996) where a Cobb–Douglas production function is estimated for the period 1964–91. Thus, the regional stock of public capital is shown to be relevant in accounting for the gains in productivity of the private sector of the economy.[8]

[8]The results obtained taking into account the elasticity estimated in Table 2 (0.1107), as well as the average growth of TFP^s (2.83% p.a.) and of the stock of public capital (5.83% p.a.) show that the growth of public capital explains approximately 23 percent of the growth of the average TFP^s of the Spanish economy.

TABLE 2

TFP[s] AND PUBLIC CAPITAL

Variables	Coefficient	*t*-Statistic ntVariables	Coefficient		
ln (*G*)*it*	0.1007	(2.078)			
Growth Rate of Technical Progress			Fixed Effects		*t*-Statistic
Andalucia	0.0275	(6.8172)	Galicia	−1.9020	(−2.8980)
Aragón	0.0255	(8.1122)	Extremadura	−1.7951	(−2.8160)
Asturias	0.0235	(6.9583)	C-Mancha	−1.6968	(−2.5728)
Balearics	0.0176	(4.1579)	C-León	−1.6247	(−2.3488)
Canaries	0.0242	(5.4778)	Andalucia	−1.6217	(−2.3364)
Cantabria	0.0223	(5.6329)	Asturias	−1.4312	(−2.2975)
C-La Mancha	0.0296	(8.4945)	Aragón	−1.4214	(−2.1564)
C-León	0.0265	(8.4950)	Murcia	−1.2997	(−2.2678)
Catalonia	0.0162	(4.2868)	C. Valenciana	−1.2963	(−1.9804)
Extremadura	0.0325	(9.9803)	Cantabria	−1.2947	(−2.2839)
Galicia	0.0318	(9.0274)	Canaries	−1.2492	(−2.0534)
La Rioja	0.0264	(7.6186)	Navarra	−1.2110	(−2.0485)
Madrid	0.0134	(3.2586)	La Rioja	−1.1948	(−2.1754)
Murcia	0.0218	(4.5799)	Basque Country	−1.1601	(−1.8311)
Navarra	0.0243	(7.1205)	Catalonia	−1.1134	(−1.6320)
Basque Country	0.0167	(3.9564)	Balearics	−0.8846	(−1.5822)
C. Valenciana	0.0213	(5.0969)	Madrid	−0.8535	(−1.2997)
R2	0.9775				
SSR	0.6272				
DW	1.6541				
SE	0.0533				

Ho: $\lambda i = \lambda$, $F(17,220) = 31.46$
Ho: Aio = Ao, $F(17,220) = 68.98$

[a] Source: GVA and Employment: BBV
Private and Public Capital: Foundation BBV/IVIE (1996)
[b] Period: 1964–93
[c] Dependent Variable: ln (*TFP*[s])*it*
[d] *t*-statistic in parentheses
[e] Estimation under the accepted restriction of Constant Returns to Scale [$(\rho - 1) = 0.0432$; *t*-statistic = 0.6576]

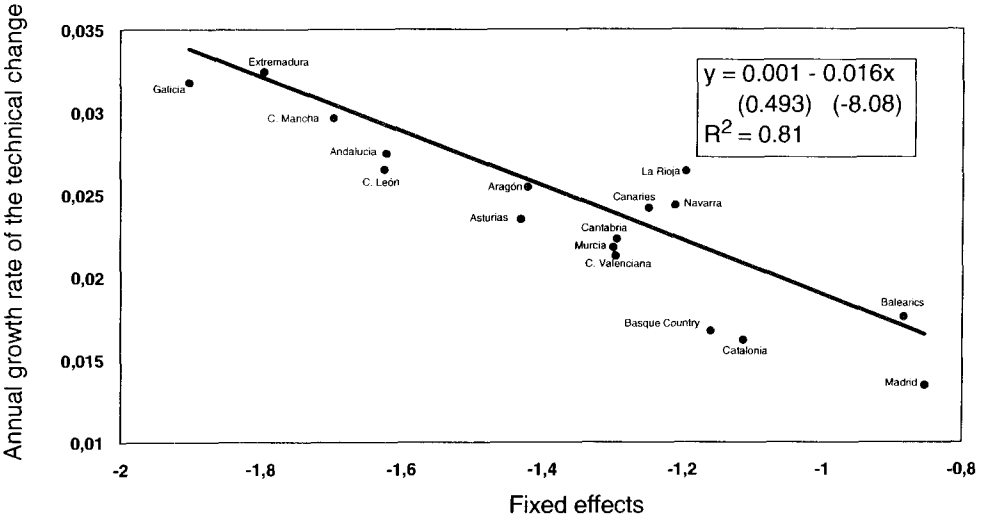
In the last line of Table 2 there appears the test value of the hypothesis, Ho : $\lambda_i = \lambda$. *F*-statistic vaue ($F(17,220) = 31.46$) enables the rejection of the hypothesis of equality of the growth rates of exogenous technical progress of the regions in the period under study. The λ_i values obtained for the regions show that they all have statistically significant positive growth rates, reaching a minimum value of 1.34 percent p.a. (Madrid) and a maximum of 3.25 percent p.a. (Extremadura).

The individual effects estimated reflect the value of a stricter measure of efficiency in the initial year (A_{i0}).[9] The right-hand side of Table 2 shows in descending order the estimated values of these regional fixed effects. Also, the results show that these effects are statistically significant in most regions, and the substantial differences among regions indicate that such differences existed in the initial levels of efficiency. It can be appreciated that the poorest regions in terms of GVA per capita (Galicia, Extremadura, C-Mancha and C-León) also present

[9]The restriction that regional fixed effects are equal across regions is also rejected ($F(17,220) = 68.98$).

lower efficiency levels than the richest regions (Madrid, Balearics and Catalonia).

On the basis of the values of the fixed effects and of the estimated λ_i, it is of interest to test again whether the regions with lowest efficiency levels in 1964 are those which have experienced higher growth rates in A_{it}, and hence whether convergence in efficiency has occurred during the period analysed. Figure 5 shows that there has been convergence in this sense, given that the relation between fixed effects and estimated growth rates is negative and statistically significant. Specifically, the R^2 of the regression is 0.81, and the slope of the regression line is -0.016 with a t-statistic of -8.08.



Source: See text. t-statistic in parentheses.

Figure 5. Beta convergence in efficiency (1964–93)

IV. Conclusions

The levels of total factor productivity (TFP^s) reached by the Spanish regions present notable differences over the whole period considered (1964–93). At the end of the period, the regions which obtain a higher combined productivity of the use of private inputs—Madrid in first place, followed by the Balearics and Catalonia—are far ahead of the more backward ones in efficiency.

The improvements in the levels of TFP^s over the period considered have contributed to explaining, on average, more than two-thirds of the expansion of production, this contribution being most important in the poorest regions (Extremadura and the two Castilles). In contrast, the regions of the Mediterranean, the islands and Madrid achieved more modest productivity gains in the use of private factors.

The other great growth factor in the Spanish regions has been the accumulation of capital, while the employment of labour made negative contributions to the expansion of output. Around 30 percent of the increase in production is

explained by the accumulation of capital, a general phenomenon in all the regions.

The detailed analysis of the TFP^s as an indicator of efficiency allows us to conclude:

1. The TFP^s may be considered to be an indicator of the gains in efficiency achieved by the private factors, capital and labour, together. However, if the contributions of the services of public capital are taken into account, it is possible to differentiate these contributions from gains in efficiency in a stricter sense. According to the estimations made, the endowments of productive public capital of a region contribute positively and significantly to the gains in private productive efficiency. Equally positive and significant is the trend which reflects improvements in efficiency not incorporated into any of the factors of production considered (exogenous technical progress). Furthermore, the different regions do not show the same levels of efficiency. The results obtained in view of the value of their fixed effects show that the regions of the north-eastern quadrant of Spain and Madrid presented the highest levels of efficiency.

2. All these differences, both in the initial positions of the regions and in the pace of improvement, can be analysed systematically through the concepts of convergence. The Spanish regions have become more alike (have converged), both in GVA per capita and in labour productivity. Their increasing similarities in the capital/labour ratio, derived from the generalized and intense process of capitalization mentioned earlier, have contributed to this. The convergence observed in the endowments of public capital of the different regions has also contributed to his homogenization.[10]

Besides, it can be affirmed that there is a definite pattern of convergence among the Spanish regions with regard to their efficiency in the use of the factors. The indicator of efficiency for the private factors TFP^s and that obtained after discounting the effect of the use of public capital (A) show that the regions which started at lower levels have improved more rapidly in this sense. Thus, the regions seem to be more alike in terms of their efficiency levels.

Appendix 1: On the Capital Stock Series

The capital stock series (private and public) used in this study are the result of an ambitious project that has had from the beginning the support of the Banco Bilbao-Vizcaya (BBV) Foundation, the body which in 1955 began the regional accounting series in Spain and which also supports their updating in the future. In September 1998 all the BBV's Spanish regional data base (including the capital stock series) became available on Internet. (http://barcoreg.fbbv.es.)

The capital stock series are currently available, on an annual basis, for the period 1964–94 and for the 17 Spanish regions (Autonomous Communities in the Spanish terminology). The stock of public capital is also available for the 50 Spanish provinces and for the same period. The statistical information does not allow this level of geographical disaggregation for private capital. The definition of capital refers to produced fixed tangible assets, and therefore excludes the value of land and also intangible assets. It distinguishes between (a) private capital; (b)

[10]These results have been shown and analysed in Mas *et al.* (1994 and 1995).

capital stock owned by the Public Administration; and (c) other infrastructures (owned mainly by public enterprises).

The private capital stock series includes twenty-three productive sectors: Agriculture; Fishing, Energy; 13 industrial sectors; Construction; Residential (dwelling); and 5 Service sectors. The Public Administration stocks includes six categories: Roads; Hydraulic Infrastructures; Urban Structures; Ports and Maritime Signalling and Education and Health. The remaining infrastructures are those close to the above but owned either by public enterprises or by private ones with public support. The categories considered in this group are: Airports; Toll Highways; Railways; and Autonomous Ports.

The procedure followed in the estimation is the one habitually used in all countries which estimate their stock of capital: the Permanent Inventory Method. This method obtains the stock of capital on the basis of the accumulation of the investment made, taking into account certain patterns of depreciation and withdrawal. The data base also provides the information on the gross investment series used in the estimation of the net stock series, at 1990 prices, by sectors and categories. It has been assumed that the withdrawals follow a Winfrey S-3 retirement pattern, which is the one habitually used in most countries that estimate the stock of capital. The selection of asset life is the most delicate one in the application of the Permanent Inventory Method. In the selection of the assets lives for each type of assets we have taken into account a broad range of information, similar to that used in other countries, provided in international comparison studies [such as Ward (1976) and Keese *et al.* (1991)]; the maximum asset life permitted by Spanish fiscal laws, since this is usually the point of departure for the selection of asset lives in most countries; and also the direct information provided by experts in each field, mainly engineers and architects. Specific asset lives have been considered for each asset. For some of them the available information allows us to distinguish only between capital goods and structures, while for others the level of disaggregation is much higher.

The definition of public capital adopted, following Gramlich (1994), focuses on ownership and refers to the Public Administration as a whole, consisting of the State, the Social Security Institutions and the Territorial Administrations (Autonomous Communities—regions—and Local Councils). When appropriate, separate information is given for each of these public agents. The basic source from which the estimates of public capital have been made is the budget settlements of the various organisations. The first information available is from 1857, being elaborated in greater detail from 1910 onwards. It should, however, be kept in mind that it has not been possible to assign to the regions, or provinces, the whole stock of public capital. The unassigned portion is about 17 percent.[11]

For the estimation of the private capital series, due to the lack of information for the long period of time needed for the strict application of the Permanent Inventory Method, it has been necessary to rely on a previous estimation made by the *Universidad Comercial de Deusto* (1968). This estimation provides the base on which to accumulate, from 1960 onwards, the investments made in each sector.

[11]A detailed description of the elaboration of the series can be found in Foundation BBV/IVIE (1996).

Whenever it has been possible, the initial estimations have been completed and modified if necessary.

Appendix 2: Growth Accounting

Solow (1957) starts by considering a production function with two factors (physical capital and labour) presenting constant returns to scale:

$$y_{it} = A_{it} F(K_{it}, L_{it}) \tag{A.1}$$

where y = output, K = private capital, L = labour and A the indicator of the efficiency of economy "i" in the use of factors at time "t". On the basis of (A.1), assuming perfect competition and maximization of profits, the total factor productivity TFP^s is calculated as a residual: the difference between output and the value given to the contribution of the inputs.

If the dots above the variables denote growth rates and s_{Ki} and s_{Li} the respective participations of capital and labour in output ($s_{Ki} + s_{Li} = 1$), the growth rate of Solow's residual (TFP^s_{it}) is expressed as:

$$(\dot{TFP}^s_{it}) = (\dot{A}_{it}) = \dot{y}_{it} - s_{Ki,t}\dot{K}_{it} - s_{Li,t}\dot{L}_{it} \tag{A.2}$$

and can be calculated as successive differences in logarithms and using average shares.[12]

$$\begin{aligned}(\dot{TFP}^s_{it}) &= [\ln TFP^s_{it} - \ln TFP^s_{it-1}] \\ &= [\ln y_{it} - \ln y_{it-1}] - [1/2(s_{Li,t} + s_{Li,t-1})][\ln L_{it} - \ln L_{it-1}] \\ &\quad - [1/2(s_{Ki,t} + s_{Ki,t-1})][\ln K_{it} - \ln K_{it-1}].\end{aligned} \tag{A.3}$$

For our analysis of regional efficiency, not only the behaviour across time of the TFP^s is of interest, but also the comparison among the levels of efficiency of regions at a given time. As had been shown by Jorgensen and Nishimuzu (1978), Denny, Fuss and May (1981), and Christensen, Cummings and Jorgensen (1981), the expression corresponding to (A.3) in relative efficiency indices would be given by equation (A.4). According to this expression, the difference between the technological level of region "i" in period "t" and region "j" in period "v" is equal to the logarithmic difference in output minus the weighted logarithmic differences of the inputs, where the shares are the simple averages of the shares in the two regions:

$$\begin{aligned}[\ln TFP^s_{it} - \ln TFP^s_{jv}] &= [\ln y_{it} - \ln y_{jv}] \\ &\quad - [1/2(s_{Li,t} + s_{Lj,v})][\ln L_{it} - \ln L_{jv}] \\ &\quad - [1/2(s_{Ki,t} + s_{Kj,v})][\ln K_{it} - \ln K_{jv}].\end{aligned} \tag{A.4}$$

From (A.4), the resulting indices of TFP^s_{it} of region "i" at time "t" can be expressed in relation to the efficiency of a "base" region ("j") in a "base" year

[12]See Diewert (1976), Jorgensen and Nishimuzu (1978), Christensen Cummings and Jorgensen (1981), Hulten and Schwab (1993).

("v"), $TFP^s_{jv} = TFP^s_{00} = 1$. In the estimations presented, Spain has been considered the "base" region and the initial year, 1964, as the "base" year.

The estimations presented refer to the private sector (excuding the energy sector) of the economy. The definition and sources for the variables considered in (A.4) are as follows:

Y_{it} = private output gross value added (GVA) at factor cost of region "i" in the year "t" at constant prices (pesetas of 1990). Source: BBV and INE.

L_{it} = employment in the private sector of region "i" in the year "t". Source: BBV.

K_{it} = stock of private productive (non-residential) capital of region "i" in the year "t" at constant prices (pesetas of 1990). Source: Foundation BBV/IVIE (1996).

s_{it} = income shares of the private inputs (private capital and labour) of region "i" in the year "t". Source: BBV.

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