Departamento de Economía Aplicada

DOCUMENTOS DE TRABAJO

UNIVERSIDAD DE JAÉN

IS THERE ANY RELATIONSHIP BETWEEN PUBLIC INVESTMENT AND ECONOMIC GROWTH IN THE SPANISH REGIONS?

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WP 0002/Nº 13

Critics and suggestions are welcome:

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(*) I would like to thank Pedro A. Lozano for his valuable help with computing.

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PRELIMINARY VERSION !!!

Diego Martínez López

Abstract: This paper offers an introduction to the empirical relationships between public investment and regional economic growth in Spain over the period 1965-1995. We use a neoclassical theoretical framework for two regions with public capital subject to congestion and spillover effects from infrastructure situated in neighbouring regions. Next we derive a convergence equation that is estimated using panel data techniques. This enables us to control unobserved specific characteristics; furthermore, we take account of possible endogeneity problems. Our provisional results suggest that public investment has not played an important role in regional growth rates during period specified.

Keywords: infrastructures, congestion, spillover, convergence, panel data.
JEL Classification: H 54, O 40, R 53.

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I. **Introduction**

Academic interest about the relationships between public capital and economic performance began, as is well known, from Aschauer´s (1989) seminar paper. Since then we find a great number of works which have examined whether there exist a positive impact of public investment on economic activity. These studies have adopted different approaches to measure this contribution and so they do not coincide with obtained results. Though most papers show a positive correlation between output and public capital or investment, they offer a large range of values for this relationship. Econometrics issues are usually behind these discrepancies. Gramlich (1994) and Draper and Herce (1994) are two surveys that prove what we have just written.

In other hand, economic growth theory advanced since latest eighties considerably because of the development in endogenous growth models. These theoretical contributions permit positive growth rates through constant returns in factors that may be accumulated. A way to generate endogenous growth is to define a production function with public capital as an argument. Some authors have treated this topic under different specifications (Barro, 1990; Barro and Sala-i-Martin, 1992, Futagami *et al*., 1993, Glomm and Ravikumar, 1994; among others).

However, we also find models that use infrastructures services in a neoclassical (exogenous) growth framework (Arrow and Kurz, 1970) and so you can test if economies converge controlling productive public spending. In this sense, one of the main objectives for regional policy is based on public investment programmes, under the assumption that this policy favour convergence among regions and countries.

This paper only pretends to offer an introduction to the empirical relationships between public investment and regional economic growth in Spain over period 1965-1995. We use a neoclassical theoretical framework for two regions and we derive a convergence equation that is estimated using panel data techniques.

This work presents new issues that they have not been treated in past papers. First, we model some aspects related to public capital such congestion and spillover effects generated by infrastructures situated in other regions that economic growth literature has not included simultaneously yet. Second, we employ a not very usual statistical technique in economic convergence: panel data methods; most papers estimate speed convergence towards steady-state and others coefficients based on a cross section analysis. In this way, our strategy will enables us to control for unobserved specific effects in each region. Third, we adopt some precautions to avoid simultaneity and very common econometrics problems which are ignored in some papers on economic growth. The paper is organised as follows. After this introduction, the theoretical model is presented. Section III discusses main estimation problems for convergence equation and finally section IV concludes.

II. A theoretical framework

As we have already said we use a neo-classical approach for studying the economic growth process in Spanish regions; so we start from Solow model. We assume a Cobb-Douglas production function for two regions (*A* and *B*):

$$\mathrm{Y}_t^{\mathrm{A}} = \left(\Psi_t L_t\right)^{1-\alpha-\beta-\gamma} \left(\mathrm{K}_t^{\mathrm{A}}\right)^{\alpha} \left(\frac{G_t^{\mathrm{A}}}{\mathrm{K}_t^{\mathrm{A}}}\right)^{\beta} \left(\frac{G_t^{\mathrm{B}}}{\mathrm{K}_t^{\mathrm{B}}}\right)^{\gamma}$$

$$\mathrm{Y}_t^{\mathrm{B}} = \left(\Psi_t L_t\right)^{1-\varepsilon-\theta-\lambda} \left(\mathrm{K}_t^{\mathrm{B}}\right)^{\varepsilon} \left(\frac{G_t^{\mathrm{B}}}{\mathrm{K}_t^{\mathrm{B}}}\right)^{\theta} \left(\frac{G_t^{\mathrm{A}}}{\mathrm{K}_t^{\mathrm{A}}}\right)^{\lambda},$$

where $\psi_t = \psi_0 e^{xt}$ y $L_t = L_0 e^{nt}$, *Y* is regional output, ψ the level of technology, *L* labour, *K* private capital and *G* productive public capital; $\alpha + \beta + \gamma < 1$ and $\varepsilon + \theta + \lambda < 1$. So we set that technology and labour grow exogenously at rates *x* and *n*. Notice that public capital enters in production function relative to private capital to consider infrastructures are subject to congestion. Furthermore we take account of the spillover effects which is generated by public capital located in others regions. Based on constant returns we can rewrite these two functions in terms of effective unit labour:

$$y_t^{A} = \left(k_t^{A}\right)^{\alpha} \left(\frac{g_t^{A}}{k_t^{A}}\right)^{\beta} \left(\frac{g_t^{B}}{k_t^{B}}\right)^{\gamma}$$

$$y_t^{B} = \left(k_t^{B}\right)^{\varepsilon} \left(\frac{g_t^{B}}{k_t^{B}}\right)^{\theta} \left(\frac{g_t^{A}}{k_t^{A}}\right)^{\lambda} .$$

Next we define movement equations for state variables as follows:

$$\dot{k}_t^{A} = (1-\tau)s_t^{A} y_t^{A} - \left(\delta + n^{A} + x\right)k_t^{A}$$

$$\dot{k}_t^{B} = (1-\tau)s_t^{B} y_t^{B} - \left(\delta + n^{B} + x\right)k_t^{B}$$

$$\dot{g}_t^{A} = ig_t^{A} y_t^{A} - \left(\delta + n^{A} + x\right)g_t^{A}$$

$$\dot{g}_t^{B} = ig_t^{B} y_t^{B} - \left(\delta + n^{B} + x\right)g_t^{B}$$

where a dot over a variable denotes differentiation with respect to time. τ is proportion of resources that government collects thorough taxes to finance public expenditure (productive and not productive), s_t^i ($i = A, B$) is saving rate in region i at t, δ is the constant and common depreciation rate and ig_t^i is fraction of income invested in public capital in region i at t.

If we express income growth rate for region A as a logarithmically differential equation, we obtain

$$\frac{d\ln y^{A}}{dt} = (\alpha-\beta)\frac{d\ln k^{A}}{dt} + \beta\frac{d\ln g^{A}}{dt} + \gamma\frac{d\ln g^{B}}{dt} - \gamma\frac{d\ln k^{B}}{dt}$$

This expression will be used to take a first-order Taylor expansion around steady-states values:

$$\ln y_t^{A} - \ln y_{t-1}^{A} = \rho\left(\ln y_{t-1}^{A} - \ln y_{E}^{A}\right) - \rho\,\gamma\,(\phi-1)\left[\ln\left(\frac{g^{B}}{g_{E}^{B}}\right) - \ln\left(\frac{k^{B}}{k_{E}^{B}}\right)\right] \qquad (1)$$

where $\rho = (1-\alpha)\left(\delta + n^{A} + x\right)$ is convergence speed towards steady-state point, $y_{E}^{A} = \left(\frac{\left(s^{A}\right)^{\beta-\alpha}\left(s^{B}\right)^{\gamma}\left(\delta + n^{A} + \delta\right)^{\alpha}}{\left(ig^{A}\right)^{\beta}\left(ig^{B}\right)^{\gamma}(1-\tau)^{\alpha+\beta+\gamma}}\right)^{\frac{1}{\alpha-1}}$ is steady-state value for per capita income in region A and $\phi = \dfrac{n^{\mathrm{B}}}{n^{\mathrm{A}}}$ pretends to capture the effects that different demography growth rates may exert on spillover.

III. Specification and estimation of convergence equation

When we develop equation (1) to get a more defined convergence equation, this can express as follows:

$$\begin{aligned}
&\ln y_{it}^{\mathrm{A}} - \ln y_{it-1}^{\mathrm{A}} = \eta \frac{\beta-\alpha}{\alpha-1} \ln s_{it}^{\mathrm{A}} + \eta \frac{\gamma}{\alpha-1} \ln s_{it}^{\mathrm{B}} + \eta \frac{\alpha}{\alpha-1} \ln\left(\delta + n_{it}^{\mathrm{A}} + x\right) - \\
&\eta \frac{\beta}{\alpha-1} \ln ig_{it}^{\mathrm{A}} - \eta \frac{\gamma}{\alpha-1} \ln ig_{it}^{\mathrm{B}} - \eta \frac{\gamma+\beta-\alpha}{\alpha-1} \ln(1-\tau) - \eta \ln y_{it-1}^{\mathrm{A}} - \\
&\rho\gamma\left(\phi_{it}-1\right)\left[\ln\left(\frac{g_{it}^{\mathrm{B}}}{g_{\mathrm{E}}^{\mathrm{B}}}\right) - \ln\left(\frac{k_{it}^{\mathrm{B}}}{k_{\mathrm{E}}^{\mathrm{B}}}\right)\right] + u_{it},
\end{aligned} \qquad (2)$$

where $\eta = 1 - e^{-\rho t}$, u_{it} is interpreted as a random disturbance and $i = A$. The next step is estimating the last equation with panel data techniques, which are not very usual in convergence topics. As we said before, this statistical method permits controlling for unobserved specific effects in each region and we avoid an estimation with biased coefficients (Islam, 1995).

Again, the term which is before random error pretends to capture the effects that different demography growth rates may exert on spillover. Since model has been designed in effective units and technical progress and depreciation rates are constants and identical to both regions, the relevant parameters for spillover effects are differences in demography growth rates.

First estimations for equation (2) did not give significant coefficients for variable $(\phi - 1)$, provoking as well that coefficient corresponding to $\delta + n_{i\,t}^{A} + x$ loses statistical significance. This can be caused by two non excluding reasons: 1) high multicollinearity in specification as consequence of the definition of ϕ $\left(\phi = \dfrac{n^{\mathrm{B}}}{n^{\mathrm{A}}}\right)$; 2) differences among regions in demography growth rates do not exert any effect on convergence and spillover relationships. To offer some evidence about this, we developed this term and we estimated a bigger convergence equation, with two new variables. The problem rose again. We implemented then a Wald test of joint significance to check whether these new variables affected to income growth rate. Null hypothesis of non significance was accepted[1].

So we are going to estimate equation (2) disregarding term situated before random error. Since panel data techniques assume individual unobserved effects, we must test previously if these individual effects are correlated or not with regressors; so a Hausman specification test provides evidence against the latter case and we choose an within-groups estimator[2]; so we will estimate a fixed-effects model.

Some authors (King and Levine, 1994; Dolado *et al.*, 1994; Gorostiaga, 1999) have pointed out that saving rate may depend to income growth; this causes a simultaneity problem between both sides in convergence equation. To solve it we have to employ an instrumental variables (IV) estimator. In this way, and since we are working with a fixed effects model (which implies variables in deviations from mean for each region, including error term), lagged explicative variables are not a good instrument. Moreover, intra-groups transformations may induce serial correlation in transformed errors. A method proposed by Arellano (1988) and Arellano and Bover (1995) suggests to express the variables in orthogonal deviations (each observation as the deviation from the average of *future* observations in the sample for the same individual and weight each deviation to standardise the variance). Furthermore Arellano and Bover (1995) show that Ordinary Least Squared after transforming in orthogonal deviations is exactly equivalent to within groups for a balanced panel (our case).

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[1] This test compute a W statistics that, under null hipothesis of non significance for two variables, has a chi-squared distribution with degrees of freedom equal to the number of restrictions. Since $W = 3.981$ is associated to a p-value = 0.136, we do not reject H_0. Whether we suppose that errors are normally distributed and independent, we can approximate the W statistics to a F distribution and the new results confirm those we have already obtained: $F = 1.99$ and p-value = 0.138 for H_0.

[2] This test computes a H statistics that, under null hipothesis of no correlation between individual effects and regressors, is distributed as a chi-squared with k degrees of freedom, where k is number of regressors. We only inform for column (1) in table 1A since remaining specifications present similar values. In that case $H = 163.23$ with a p-value = 0.00.

A Granger causality test has been run for each region to assess whether simultaneity problem exists. Despite of limitations of this test we are able to infer that there is such situation at conventional significance levels in two regions only. Anyway, we are going to use some IV estimators to cover also possible endogeneity problem related to public capital and public investment, as it has been pointed out by several papers (see, for example, Gramlich, 1994 and Draper y Herce, 1994 for a survey). For an optimal choice of instruments matrix we have used the Generalised Method of Moments (GMM) (see, *inter alia*, Arellano and Bover, 1995).

Previously we have estimated convergence equation in restricted form, i. e., imposing the restriction that the coefficients of investment and population growth variables are equal in magnitude and opposite in sign. This is a very often condition in empirical economic growth papers. Though this null hypothesis is accepted by a Wald test[3], efficiency gains derived from imposing it were very small; so we have decided to employ unrestricted model. In other hand, all standard errors and test statistics are robust to heteroskedasticity, except for dummies case. Tests for first-order serial correlation in residuals are not reported but are available on request. In this sense, we have not found any evidence for first-order serial correlation in residuals[4], except for specification (6). We describe used variables in data appendix.

Tables 1A and 1B report results for different specifications and assumptions in convergence equation, all in orthogonal deviations. Column (1) offers no IV estimation. Columns (2)-(4) present GMM estimation and column (6) show what happens when time and regional dummies are included. A Sargan test for overidentifying restrictions is also included where a GMM estimator is used (See Arellano and Bond (1991) for a further discussion).

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[3] See footnote 1. The values corresponding to statistics W y F are: W = 0.603 and F = 0.603, both of them associated to a p-value = 0.43.

[4] These tests are based on the fact that if the disturbances are not serially correlated, there should be evidence of significant negative first order serial correlation in the differenced residuals, and no evidence of second order serial correlation in the differenced residuals. Under the null hypothesis of no correlation, two statistics made as proposed by Arellano and Bond (1991) have an asymptotically distribution N(0,1).

Table 1A: Estimation of a convergence equation for Spanish regions (1965-1995). Dependent variable is per capita income growth rate.

	DEV (1)	DEV GMM (All) (2)	DEV GMM (s^A, ig^A) (3)
Y_{t-1}	-0.1412 (-15.85)	-0.1457 (-16.22)	-0.1428 (-15.57)
S^A	0.0319 (3.52)	0.0344 (3.28)	0.0396 (3.14)
$\delta + n + x$	-0.0259 (-4.60)	-0.0175 (-2.53)	-0.0286 (-4.72)
S^B	0.0543 (3.40)	0.061 (3.74)	0.050 (3.09)
IG^A	0.0012 (0.23)	0.0024 (0.46)	0.004 (0.41)
IG^B	0.0021 (0.29)	0.0010 (0.12)	-0.0010 (-0.08)
τ	-0.2757 (-7.38)	-0.2931 (-7.47)	-0.2828 (-7.47)
ρ	0.066	0.068	0.066
α	0.155	0.189	0.166
β	0.007	0.013	0.024
γ	0.012	0.005	-0.005
Sargan/RSS	N. A./0.0841	174.38[78]/0.084	159.71 [26]/0.084
Wald (joint)	1344.71 [7]	1301.96 [7]	1109.43 [7]
Wald (Time D.)	N. A.	N. A.	N. A.
Wald (Reg. D.)	N. A.	N. A.	N. A.

Notes: t-statistics between parentheses and degrees of freedom between brackets. RSS are residuals sum of squared. Wald test of joint significance for regressors and time and regional dummies are reported.

Table 1B: Estimation of a convergence equation for Spanish regions (1965-1995). Dependent variable is per capita income growth rate.

	DEV GMM (s^A, ig^A, δnx) (4)	DEV GMM (s^A) (5)	DEV Reg. & Time dummies (6)
Y_{t-1}	-0.1458 (-17.78)	-0.1432 (-16.52)	-0.1048 (-4.66)
S^A	0.0379 (3.57)	0.0449 (3.92)	0.0034 (0.60)
$\delta + n + x$	-0.0170 (-2.18)	-0.0288 (-5.52)	-0.0298 (-3.47)
S^B	0.0529 (3.37)	0.0468 (2.98)	0.0011 (0.11)
IG^A	0.0035 (0.47)	0.0007 (0.13)	0.0032 (0.89)
IG^B	-0.0013 (-0.15)	0.0014 (0.19)	0.0072 (0.85)
τ	-0.2915 (-8.31)	-0.2875 (-7.70)	-0.1512 (-0.88)
ρ	0.068	0.066	0.049
α	0.104	0.167	0.216
β	0.021	0.004	0.023
γ	-0.008	0.008	0.053
Test Sargan/RSS	162.75 [39]/0.084	150.08 [13]/0.085	N. A./0.022
Wald (joint)	1237.56 [7]	938.19 [7]	58.46 [7]
Wald (Time D.)	N. A.	N. A.	486.68 [14]
Wald (Reg. D.)	N. A.	N. A.	36.00 [16]

Notes: t-statistics between parentheses and degrees of freedom between brackets. RSS are residuals sum of squared. Wald test of joint significance for regressors and time and regional dummies are reported.

We derive some provisional commentaries from two above tables:

a) The signs for variables are in general the predicted ones by theoretical model. However, we must notice what happens with variable s^B. As you can see this variable appears significant and positive in above tables, despite that infrastructures are congested by private capital and this reduces spillover effects. This is one of the pending issues that we must improve in next papers.

b) The rate of convergence (ρ) presents values between 0.04 and 0.07. They are slightly higher than cross-section analysis (Barro, 1991; Barro y Sala-i-Martin, 1991, Mankiw *et al.*,

1992) but similar results are obtained in earlier papers (Islam, 1995; Evans y Karras, 1996) that employ panel data approach. These values are different than obtained by Gorostiaga (1999). She includes in the theoretical framework both public capital and human capital and, under several specifications, she estimates very high rates of convergence for Spanish regions: about 17-18 per cent.

c) The variable ig^A is positive across different specifications but she shares a common feature: not significant at standard level. This is one of the most important results in this paper. It seems that public investment *has not* increased regional per capita income in Spain during period 1965-1995. A simple correlation coefficient shows what multivariate regression has already confirmed: there is a very weak relationship between public investment and regional income growth rate (De la Fuente and Vives, 1995).

d) For ig^B we have a similar conclusion: public capital installed in other regions does not affect to income growth rate. We can infer even that spillover from infrastructures situated in different places have had a negative impact on regional growth (columns 3 and 4). We defined this variable in a different sense, considering that such externalities arise not only from infrastructure placed in adjacent regions, but national public capital stock minus the region *A* one and the results confirmed what we have reached in the first specification.

e) Since structural character of convergence equation we can retrieve elasticities of regional per capita income with respect to the production factors. This is one of the weakest points in this work. We can see that obtained values for α, β and γ are very low, specially for α. This issue can be caused by several circumstances: 1) Private capital effects on infrastructure subjected to congestion –such we have modelled- may reduce importance of this factor in production process; 2) We have identified a theoretical variable as saving rate to empirical variable as investment rate and this assumptions is often violated with open economies, such Spanish regions are; this reveals an incomplete design for theoretical model; 3) Investment share in GDP for most Spanish regions is near to estimated values for α , so the obtained elasticities of output with respect to private capital maybe realistic.

f) Sargan test of overidentifying restrictions rejects strongly null hypotheses of the validity of the instruments[5]. There are reasons to think we do not need an instrumental estimator in this case because endogeneity problem seems not to exist.

[5] It happens the same when we have used different instruments sets, extending the lagged for instrument variables.

IV Summary and future extensions

The aim of this paper has been to discuss the relationships between public investment and economic growth in Spanish regions over 1965-1995. We have used a neoclassical framework for two regions and we have derived a convergence equation that is estimated using panel data techniques. Main new issues in this paper are modelling congestion in infrastructure, including interregional spillover from public capital situated in other regions, and estimating a convergence equation through a not very usual statistical method in this topic: panel data techniques.

We have found rates of convergence between 0.04 and 0.08. Though they are higher than cross section analysis, our methodology avoids biased coefficients and permits control for unobserved individual effects. Also we have studied a possibility pointed out by recent papers: endogeneity problem among income growth rate and some regressors, specially saving rate and public investment. A Generalised Method of Moments has been running to choice an optimal instrumental variables set. Neither Granger causality test nor Sargan test have confirmed this simultaneity between both sides of equation.

The results of our estimation show that public investment has not played an important role in regional development. Infrastructure effects on economic growth have been very small and not significant from a statistical view. It happens the same with externalities derived from public inputs placed in other regions; even sometimes we find a negative impact on growth rate in neighbouring regions. The elasticities of output respect private capital are lower than conventional values.

Some questions remain without an answer. Is it correct the theoretical treatment given to private capital? Why private capital share in GDP are so low? Is not there a simultaneity problem between income growth and saving rate or public investment actually? Do our results mean that capital public spending has not favoured regional development in Spain over period 1965-1995?

Data appendix

y_{it}: Log of income per working-age population in region *i* for year *t*.

s^A: Log of share of private investment in GDP in region *A* for year *t*.

s^B**:** Log of share of private investment in GDP in a set of adjacent regions to *A* for year *t*. For Baleares and Canary Islands we have considered national total minus value corresponding to these regions, respectively.

$\delta + x$**:** Log of depreciation and technological growth rates. Value fixed in 0.07. Estimation is robust to changes in this parameter.

n_{it}**:** Log of working-age population growth in region *i* for year *t*.

ig^A**:** Log of share of public investment in GDP in region *A* for year *t*.

ig^B**:** Log of share of public investment in GDP in a set of adjacent regions to *A* for year *t*

τ**:** Log of share of resources that government collects thorough taxes in GDP.

Sources: Foundation BBV and IVIE. All variables are measured in 1986 pesetas. Time series are constructed for biennial observations.

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Diego Martínez López

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Diego Martínez López

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