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Public Infrastructures and Regional Asymmetries in Spain

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Abstract

The objective of this paper is to investigate the effects of public infrastructure on regional economic performance in Spain. The empirical results are based on VAR models relating output, employment, private capital, and public infrastructure. We estimate models at the aggregate level and for each of the 17 regions of Spain. In the regional models, both public infrastructure in the region and public infrastructure elsewhere are considered, thereby taking into consideration the possible existence of regional spillovers. Our empirical results show that regional spillovers are very important, and that although public infrastructure has been a powerful instrument to promote long-term growth, it has done so in a way that is unbalanced across regions. This means that aggregate convergence in Spain to EU standards of living has been achieved at the cost of increased domestic asymmetries.

JEL Codes: C32, H54, and R53

Keywords: public infrastructure, regional spillovers, regional asymmetries

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PUBLIC INFRASTRUCTURE AND REGIONAL ASYMMETRIES IN SPAIN

1. Introduction

In this paper we focus on the impact of public infrastructure investment in Spain with the objective of identifying its effects on regional economic activity. The backwardness of the Spanish economy relative to its European Union partners led to the establishment of the EU Structural Funds Programs for Spain in 1989. The cornerstone of these programs has been the development of a modern infrastructure in order to improve accessibility among regions and to external markets. In general, these programs are aimed both at promoting convergence of the domestic economy to EU standards of living and at reducing domestic and international regional asymmetries. Indeed, about two-thirds of the funds allocated by the EU for structural transfers for the period of 2000-06 where targeted at the so-called Objective 1 – helping regions whose development is lagging behind to catch up. This is also true about Spain where, for the same period, 63.6% of the EU Structural Funds were allocated directly to helping lagging regions (for further details on the regional policies in the EU in general and for the Spanish case in particular see, for example, http://ec.europa.eu/regional_policy/index_en.htm).

It is now a well-established fact that public infrastructure has been a powerful instrument to promote long-term growth in Spain and therefore an important tool in bringing the Spanish economy up to EU standards (De la Fuente [1996]). Despite this evidence, the question of the impact of public infrastructure in Spain at the regional level and the relation between the regional and aggregate effects remains unanswered (see Cantos et al. [2005] for a review of the relevant literature). This is a critical issue though, since the relevance of the aggregate effects does not provide any information as to the regional incidence of these effects. Significant positive aggregate effects could be associated with balanced positive effects across regions or could mask uneven regional gains. Our central question, indeed, is to determine whether aggregate growth has been accomplished in a manner that is regionally balanced or rather has been accomplished by increasing regional asymmetries.

To address this issue, we follow the VAR approach to the analysis of the effects of public capital developed for the US in Pereira and Flores (1999) and Pereira (2000, 2001) (see Kamps [2005] for a review of this literature). Empirical results are based on impulse-response functions associated with VAR estimates relating output, employment, private capital and public infrastructure. This approach highlights the importance of dynamic feedbacks among the different variables as well as the possible endogeneity of public infrastructure. Furthermore, in addition to the analysis of the effect of public infrastructure on output, it allows for the analysis of the effects on private capital and employment, something largely neglected in the literature.

Methodologically, this paper directly builds upon Pereira and Roca-Sagales (2003). In that paper we investigate the possible existence of regional output spillover effects of infrastructure capital in Spain, that is, the possibility that output in a given region may benefit from public infrastructure elsewhere. To do so, we estimate independently eighteen VAR models, one for each of the Spanish autonomous regions and one for Spain as a whole. The regional-level VAR models relate output, employment, private capital,

and infrastructure installed in the region as well as infrastructure installed elsewhere. In this approach no consideration is given to geographical proximity of the different regions. We would not expect this to be a problem given the relatively small size of the country. Furthermore, we are focusing essentially on transportation and communication infrastructure for which it is reasonable to assume that the any part of the network is connected to the entire network.

Empirical results in Pereira and Roca-Sagales (2003) suggest that the aggregate effects of public infrastructure on output cannot be entirely captured by the direct effects for each region from public infrastructure installed in the region itself but that when spillover effects are also considered, the disaggregated effects are very much in line with the aggregate effects. Ultimately, the aggregate effects on output are due in almost equal parts to the direct and spillover effects of public capital, which establishes the relevance of regional spillovers in Spain (see Pereira and Andraz [2004] for a discussion of the US case).

This paper is organized as follows. In section 2 we present the data and preliminary results. In section 3, we present estimates of the aggregate effects of public infrastructure as a benchmark for our regional evidence. In section 4, we present the main evidence on the regional decomposition of the effects of public infrastructure on private capital, employment, and output and analyze its impact on the concentration of economic activity. Finally, in section 5, we offer some concluding remarks.

2. Data and preliminary results

In this section we first present the data set as well as the relevant preliminary empirical results – unit root and VAR specification tests. Then, we briefly discuss the identification of exogenous innovations in public infrastructure and the indicators used to measure the effects of such innovations. For the sake of brevity no details are formally presented about these results. They are, however, readily available from the authors upon request.

2.1 Data: sources and description

We consider annual data on output, employment, and private capital, as well as public infrastructure both at the aggregate and regional levels. In the regional disaggregation we consider the seventeen autonomous regions that make up Spain: Andalucía, Aragón, Asturias, Baleares, Canarias, Cantabria, Castilla-León, Castilla-Mancha, Cataluña, Extremadura, Galicia, Madrid, Murcia, Navarra, Rioja, Valencia, and País Vasco. Of these regions, fifteen are located in continental Spain in the Iberian Peninsula, while Baleares and Canarias are archipelagos off the coast of Spain in the Mediterranean and the Atlantic, respectively.

The data covers the sample period of 1970 to 1995. All variables, except for employment, are in million of constant 2001 euros. Employment is measured in thousands of workers. The data is obtained from several sources, although for each variable the same source is used for both aggregate and regional data. Output for the period 1980-1995 is obtained from the regional account information, "Contabilidad Regional de España" (INE, 2000). Using this information and the regional information presented in FBBV (1999) and the national accounting information in "Contabilidad Nacional de España" (INE,

2000), we obtain the regional output for the period 1970-1979. In turn, employment is obtained from "Encuesta de Poblacion Activa" (INE, 2000). Finally, private capital and public infrastructure are obtained from FBBVA (2001). Public infrastructure includes transportation infrastructure - roads, ports, airports, and railroads, as well as communications infrastructure. It is a comprehensive measure in that it includes infrastructure owned by the national, regional, and local administrations.

Some summary indicators for the regional data are provided in Table 1. Most regions are very small. Indeed, Asturias, Cantabria, Extremadura, Murcia, Navarra, and Rioja, together account for just about 11% of the Spanish output, private capital, employment, and public infrastructure. In turn, Andalucía, Castilla-León, Cataluña, Madrid, Valencia, and País Vasco, are the six largest regions and concentrate 70.4% of the Spanish output, 69.4% of the private capital stock, 66.3% of employment, and 64.8% of the public infrastructure. Finally, it is also important to note that there are clear regional differences in terms of the relative concentration of public infrastructure. Regions such as Aragón, Asturias, Castilla-León, Castilla-La Mancha, Navarra and Rioja have a disproportionately high concentration of infrastructure compared to their regional output while the opposite is true for regions such as Baleares, Madrid and Murcia.

2.2 Univariate analysis

In order to determine the order of integration of the different variables, we test the null hypothesis of a unit root on regional and aggregate output, private capital, employment, as well as public infrastructure in their logarithmic form. The results are based on the Augmented Dickey-Fuller (ADF) t-test. The optimal lag structure is chosen using the Box Information Criterion (BIC). A deterministic component is considered if statistically significant.

The analysis of the different series clearly suggests that output and employment in log-levels are I(1) at both the aggregate and regional levels. In turn, the evidence for the private capital and public infrastructure is mixed, with the results suggesting that some of the disaggregated series are I(1) and others I(2). To clarify this issue, we follow the procedure adopted in Pereira and Flores (1999) and apply the unit roots tests to the logarithms of the ratios of private capital and public infrastructure to output. Since output is I(1), if these ratios are I(1) it follows that the private capital and public infrastructure series are I(1) as well. The test results suggest that the logarithms of the ratios of private capital to output are I(1) at the aggregate level and for all the regions. In turn, the logarithms of the ratios of public infrastructure to output are I(1) at the aggregate level and for 14 of the 17 regions. Furthermore, the ADF Z-test suggest public infrastructure to output series to be I(1) in all cases. We take these results as strong evidence that stationarity in first differences is a good approximation for all time series under consideration, both at the aggregate and at the regional levels.

2.3 VAR specifications

We estimate independently eighteen VAR models. The first is an aggregate VAR model for the whole country, which includes aggregate public infrastructure, in addition to output, private capital, and employment. This model is designed to give us the overall picture on the effects of public infrastructure. Our objective, however, is to uncover the regional incidence of these aggregate effects. To do so, we

estimate seventeen region-specific VAR models, which include regional output, private capital, and employment, as well as two measures of public infrastructure. Naturally, for each region we consider public infrastructure in the region. However, in order to take into account the possible existence of regional spillover effects we also consider public infrastructure installed in the rest of the country. Given the evidence of stationarity in first differences of all variables, and following the standard procedure in the literature, all the VAR estimates are in first differences of log-levels, i.e., in growth rates.

At the aggregate level, both BIC and likelihood ratio tests suggest a second-order specification with a constant and a trend. This is consistent with the fact that five of the eleven statistically significant coefficients are second order parameters, and three of the eight deterministic component parameters are statistically different from zero. In turn, using the same two tests a second order specification is selected for ten of the seventeen regions. For the remaining seven regions, Andalucía, Baleares, Castilla-León, Castilla-La Mancha, Cataluña, Murcia, and Valencia, a VAR specification of first order is selected.

2.4 Identifying and measuring the effects of innovations in public infrastructure

We use the impulse-response functions associated with the estimated VAR models to examine the effects of innovations in public infrastructure. We consider the effects of one-percentage point, one-time innovation in the rate of growth of public infrastructure. In this context, our methodology allows dynamic feedbacks among the different variables to play a critical role. This is true in both the identification of innovations in the public infrastructure and the measurement of the effects of such innovations.

The central issue for the determination of the effects of public infrastructure is the identification of shocks that are not contemporaneously correlated with shocks in the private sector variables, i.e., shocks that are not subject to the reverse causation problem. In dealing with this issue we draw from the approach typically followed in the literature on the effects of monetary policy (see, for example, Christiano, Eichenbaum and Evans [1999], and Rudebusch [1998]). This approach was adapted to the analysis of the effects of public capital formation in Pereira (2001) (see Pereira and Roca-Sagales [2003] for details of the general methodology as well as its application to the Spanish case.)

We report the long-term elasticities with respect to public infrastructure. Long term is defined as the time horizon over which the growth effects of innovations disappear. In our analysis, we assume that long term means twenty years, although most impulse response functions converge in between five and ten years. These elasticities represent the total percentage point changes in output for one long-term percentage-point change in public infrastructure.

We also report the long-term marginal products of public infrastructure. These figures measure the long-term accumulated change in private-sector variable per one euro of long-term change in public infrastructure. We obtain each figure by multiplying the long-term elasticity by the corresponding output to the public capital ratio. This ratio is in the original levels of the variables and is the average ratio for the last ten years of the sample. This allows us to interpret the marginal product figures as the long-term effects of policies implemented at the end of the sample measured under the conditions observed by the end of the sample period. Finally, it should be noted that at the regional level the marginal product figures are weighted figures. This means that each raw regional marginal product figure has been multiplied by

the share of public capital in that region in total public capital in Spain. This allows us to interpret the sum on the regional marginal products as the combined effect of one euro in aggregate public infrastructure and makes the disaggregated figures directly comparable to the marginal products obtained from the aggregate model.

3. On the aggregate effects of public infrastructure

We start by estimating the effects of public infrastructure at the aggregate level for the whole Spanish economy. Although this is not the focus of the paper, it is an important step since it gives us a benchmark for the effects of public infrastructure and establishes the general credibility of our results. We obtain the aggregate results from the impulse response functions associated with the VAR model relating aggregate output, private capital, employment, and public infrastructure. Overall, our results confirm the conventional wisdom that public infrastructure has an important positive effect on long-term economic performance in Spain.

The long-term accumulated elasticities of private capital and employment with respect to public infrastructure are 0.270 and 0.414, respectively. Accordingly, public infrastructure crowds in both private capital and employment. In turn, the long-term accumulated elasticity of output is 0.523. This means that the marginal productivity of public infrastructure is 2.892, or that a one-euro increase in public infrastructure leads to a long-term accumulated increase in private output of 2.892 euros. Another way of interpreting this figure is by considering that if the average life expectancy of public infrastructure is twenty years, then investment in public infrastructure has an average rate of return of 5.5%. These results show that public infrastructure has a significant positive effect on aggregate output.

The comparison of these results with the evidence in the literature is not easy. This is primarily because the literature has used a variety of econometric techniques, which makes similar terms, like elasticity or marginal product not always comparable with the way such terms are used in this paper. Although comparisons are difficult, they are not impossible. In terms of the impact of public infrastructure on output, our estimate of the elasticity is well within the range of estimates available for Spain, which is somewhere between 0.19 and 0.71 (see De la Fuente [1996] for details). In turn, our estimate of the marginal product, i.e. 2.892, is higher but of the same order of magnitude as the one estimated in Pereira (2000) for core infrastructure in the US, i.e. 1.97. In turn, the positive effects of public infrastructure on private capital is consistent with the evidence for a group of OECD countries in Argimón et al (1997) and Pereira (2001), for the US in Aschauer (1989), and for Spain in Pereira and Roca-Sagales (2001). Finally, the positive effects of public infrastructure on employment are consistent with the evidence in Demetriades and Mamuneas (2000) for a group of OECD countries, Aschauer (2001) for the US, and Pereira and Roca-Sagales (2001) for Spain.

4. On the regional effects of public infrastructure

The ultimate objective of this paper is to identify the regional effects of public infrastructure. Therefore, and according to the methodology presented in Pereira and Roca (2003), we estimate for each

region the accumulated elasticities and marginal products associated both with innovations in the public infrastructure in the region and with innovations in public infrastructure installed elsewhere.

4.1 Regional effects of public infrastructure on private capital

Let us consider first the effects of public infrastructure on private capital (see Tables 2 and 3). The long-term accumulated elasticities of regional output with respect to public infrastructure in the region itself range from –0.627 to 0.782 and are positive in twelve of the seventeen regions. In turn, the long-term accumulated elasticities of regional private capital with respect to public infrastructure elsewhere range from –0.376 to 0.660 and are positive in fifteen of the seventeen regions.

We are now in a position to consider for each region the total marginal product, i.e., the sum of the marginal products of public infrastructure in the region and of public infrastructure elsewhere. This total marginal product measures the regional impact of aggregate public infrastructure. We find that aggregate public infrastructure crowds in private capital in fourteen of the seventeen regions. The exceptions are the small regions of Asturias, Cantabria, and Navarra, which display negative albeit low effects. In turn, Cataluña, Madrid, Valencia, and País Vasco, are the regions that show the largest effects on private capital with marginal products of 1.020, 1.782, 0.850, and 1.040 euros, respectively. These results are consistent with other evidence in the literature that in the case of Spain, public infrastructure does not seem to crowd out private capital (see, for example, Pereira and Roca-Sagalés [1999] and Boscá, Escribá and Murgui [2002]).

It is informative to consider the relevance of the spillover effects in the context of the effects of public infrastructure on private capital formation. Of the aggregate effect obtained by summing the marginal products across regions, the direct regional effects correspond to 42.6% of the total and the spillover effects to 57.4%. This suggests that the spillover effects are very important and account for more than half of the total effects of public infrastructure on private capital formation. Furthermore, spillover effects are more important than the direct effects for twelve of the seventeen regions.

4.2 Regional effects of public infrastructure on employment

Let us consider now the effects on employment (see Tables 2 and 4). The long-term accumulated elasticities of employment with respect to public infrastructure in the region itself range from –0.759 to 1.421 and are positive in twelve of the seventeen regions. In terms of the responsiveness of employment in a region to public infrastructure elsewhere we also obtain positive effects in twelve of the seventeen regions. The range of variation is from –0.700 to 0.725. This diversity of results in terms of the regional responsiveness of employment to public infrastructure is consistent with other evidence in the literature (see, for example, Pereira and Roca-Sagalés [1999] and Boscá, Escribá and Murgui [2002]).

As to the total marginal products, the total effect of both public infrastructure in the region and elsewhere, we find that public infrastructure crowds in employment in eleven of the seventeen regions. In absolute terms the regions that benefit the most are Andalucía, Canarias, Madrid, Valencia, and País Vasco which gain 8.6, 9.3, 8.9, 5.8 and 10.9 new jobs per million euros in public infrastructure investment, respectively.

Of the total effects obtained by summing the marginal products across regions, the direct regional effects correspond to 74.4% and the spillover effects correspond to just 25.6%. Furthermore, spillover effects are more important than the direct effects for only four of the seventeen regions. This suggests that in the case of employment spillover effects are not that important. This is consistent with the evidence of low intra-regional labor mobility in Spain (see for example Castillo et al. [1998] and Bentolila [1997]).

4.3 Regional effects of public capital formation on output

Finally, let us consider the regional effects of public infrastructure on output (see Tables 2 and 5). The accumulated elasticities of output with respect to public infrastructure in the region range from –0.364 to 0.604 and are positive in thirteen of the seventeen regions. A casual look at the marginal products suggests that Andalucía, Castilla-León, Cataluña, Madrid, Valencia, and País Vasco benefit substantially from public infrastructure located in their jurisdiction. In turn, the elasticities with respect to public infrastructure elsewhere range from –0.151 to 0.851 and are positive in all but one region. As measured by the marginal products Andalucía, Cataluña, Galicia, Madrid, Valencia, and País Vasco are the regions that benefit the most from public infrastructure located outside their jurisdiction.

The overall effects on output of aggregate public infrastructure in Spain are positive in all but two regions, Asturias and Extremadura. Accordingly, the positive aggregate effects of public infrastructure reflect positive regional effects for most regions. The regions that benefit the most in terms of output gains are the six largest in the country, Andalucía, Castilla-León, Cataluña, Madrid, Valencia and País Vasco, with long-term accumulated marginal products of 0.549, 0.220, 0.293, 0.560, 0.374, and 0.518, respectively. In general our empirical results are consistent with other empirical evidence for the Spanish case (see, for example, Pereira and Roca-Sagalés [1999], Pereira and Roca-Sagalés [2003], and Álvarez, Orea y Fernández [2003]).

Having identified the overall effects of public infrastructure on output we now consider the relative importance of the spillover effects. The sum across all the regions of the marginal products of the public infrastructure in the region is 46.7% of the aggregate marginal product while the spillover effects correspond to 53.3%. Therefore, the spillovers are slightly larger than the direct effects. Furthermore, spillover effects are more important than the direct effects for ten of the seventeen regions.

4.4 On the Effect of Public Infrastructure on the Concentration of Economic Activity

We have established that public infrastructure has a positive impact on long-term aggregate economic performance. We have also established that most, but not all, regions benefit from public infrastructure and we have identified which regions benefit the most in absolute terms. Now we want to determine which regions benefit the most in relative terms compared to the size of the region. We want to determine the impact of public infrastructure on the concentration of economic activity and, ultimately, on regional asymmetries. The question we want to address is whether or not the positive aggregate effects are evenly distributed regionally. In Table 6 we present for each region the ratio of the size of the effects of public investment, as measured by their share of the total effects, to the size of the region, as measured by its share of the country's private sector variable in question.

The largest effects in terms of private capital occur in Cataluña, Madrid, Valencia, and País Vasco. Of these, Madrid, Valencia and País Vasco benefit greatly in relative terms in that they represent 29.9% of Spanish private capital but reap 56.1% of the effects of public infrastructure on private capital. In addition, the smaller regions of Baleares, Canarias and Rioja, which represent just 6.5% of the Spanish private capital, also benefit disproportionately, in that they capture 9.8% of the effects. All the remaining regions lose in relative terms. Therefore, public infrastructure investment in Spain has contributed to the regional concentration of the stock of private capital in the six regions mentioned above to the detriment of the other eleven regions.

In terms of the effects on employment, the regions that benefit the most are Andalucía, Canarias, Madrid, Valencia, and País Vasco. These five regions plus Baleares, Cantabria, Murcia, Rioja, benefit substantially in relative terms compared to their share of Spanish employment. These nine regions represent about half of total employment but they capture the bulk of the positive employment effects of public infrastructure. It is important to note that public infrastructure seem to actually shift employment away from Castilla-León and Cataluña, two of the largest regions as well as from Asturias, Castilla-La Mancha, Extremadura, and Galicia. Therefore, public infrastructure has greatly affected the regional patterns of employment.

Finally, in terms of the effects on output, the regions that benefit the most in absolute terms are the six largest in the country, Andalucía, Castilla-León, Cataluña, Madrid, Valencia and País Vasco. Of these, only Cataluña benefits less than proportionally relative to its output share. The remaining five capture 70.8% of the total effects of public infrastructure in the country but represent only 45.1% of its output. Therefore, our results suggest that public infrastructure investment has contributed to the increased concentration of economic activity in most of the largest regions. These and the smaller regions of Baleares, Cantabria, Canarias, Castilla-Mancha, and Murcia are the big winners in relative terms.

It is important to note that, besides the archipelagos of Baleares and Canarias, the eight continental regions that benefit from public infrastructure more than proportionally to their share of the Spanish output, form the central spinal chord of the Iberian Peninsula, away from the borders. In turn the regions that benefit less than proportionally to their share of the Spanish GDP are invariably peripheral regions. Of these, Extremadura and Galicia, are along the Portuguese border and Aragón, Asturias, Cataluña, Navarra, and Rioja, are Northern regions closer to the French border. In all cases one could conjecture that their productive system would be relatively less dependent of infrastructure located in Spanish territory and more on public infrastructure in the surrounding countries.

As a final note, it could be conjectured that the relatively large gains identified above for some regions could just be a consequence of the disproportionately large size of public infrastructure in these regions. This is, in fact, the case for Cantabria, Castilla-León, and Castilla-Mancha. For the remaining regions, however, the opposite is true. Indeed, the share of the benefits for Andalucía, Madrid, Valencia, and País Vasco, are clearly in excess to their share of the Spanish public infrastructure and not just of their share of output. Among the smaller regions the same is true for Baleares, Canarias and Murcia. This suggests that it is the very economic structure of these regions and their connections to other regions that allows them to benefit relatively more from public infrastructure in the country.

5. Summary and concluding remarks

In this paper we analyze the regional effects of public infrastructure in Spain with the ultimate objective of determining whether or not the aggregate effects of public infrastructure are evenly distributed regionally. The empirical results are based on VAR estimates at both the aggregate and regional levels using output, employment, and private capital, as well as public infrastructure. We start by estimating the effects of public infrastructure at the aggregate level. We find that public infrastructure crowds in both private capital and employment. In addition, the long-term marginal product of public infrastructure is 2.892 euros, which corresponds to a rate of return of 5.5%. This suggests that public infrastructure has been a powerful instrument to promote long-term growth in Spain as well as the help the convergence of the Spanish economy to EU standards of living.

Moreover, our empirical results show that most regional effects mirror the aggregate effects in that most of the direct effects from public infrastructure in the region and/or the spillover effects from public infrastructure elsewhere are positive. Overall, we find that the spillover effects of public infrastructure on output and private capital are very important in that they account for over half of the aggregate effects of public infrastructure. Spillovers seem to be much less important in the case of employment.

Naturally, different regions benefit from public infrastructure to different degrees. We are particularly interested in identifying the regions that benefit more than proportionately to their size. Our results show that the positive aggregate effects of public investment are distributed rather unevenly regionally. We show that among the largest regions, Andalucía, Castilla-León, Madrid, Valencia, and País Vasco, benefit more than proportionally than their share of the Spanish GDP, while among the smallest regions the beneficiaries are Baleares, Canarias, Cantabria, Castilla-Mancha, and Murcia. Accordingly, public infrastructure has contributed to the concentration of economic activity in these ten regions, to the detriment of the remaining seven. This is particularly important since five of the ten regions that benefit the most in relative terms are among the six largest in the country.

These results open the door to some tantalizing research issues. Since public infrastructure in a given region impacts positively the economic performance of other regions and since each region benefits from public infrastructure in the region and elsewhere, one would want to know which locations have the greatest effects on the aggregate. This is a critical question if the overriding objective of a country is to increase its standards of living. On the other hand, if the reduction of regional asymmetries is an important priority, then one would want to know which locations would serve best this objective.

Finally, it should be pointed out that although our results are important from the perspective of policy-making in Spain, their interest is far from parochial. In fact, there are a number of countries that have recently joined the EU, which have levels of development, industrial environment and infrastructure scarcities that are not unlike the Spanish case in the early 1980s. Furthermore, these countries are expected to benefit from large EU structural funds upon accession, much like Greece, Ireland, Portugal, and Spain currently do. From this paper we learn that the general strategy of investing in public infrastructure may be very effective in promoting real convergence of these economies to EU standards. We also learn, however, that care must be taken in designing programs that do not achieve national converge to the EU standards at the cost of increased domestic asymmetries.

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Table 1: Data description

(1970-1995 average)	GDP (% of Spain)	Private Capital (% of Spain)	Employment (% of Spain)	Public Infrastructure (% of Spain)
Spain	100.0%	100.0%	100.0%	100.0%
1. Andalucía	13.3%	13.7%	14.2%	14.4%
2. Aragón	3.4%	3.4%	3.4%	4.5%
3. Asturias	2.7%	3.1%	3.1%	4.5%
4. Baleares	2.2%	2.5%	1.9%	1.4%
5. Castilla León	6.3%	6.8%	7.1%	9.4%
6. Castilla La Mancha	3.7%	4.0%	4.3%	5.3%
7. Canarias	3.5%	3.3%	3.4%	3.3%
8. Cantabria	1.4%	1.6%	1.4%	1.7%
9. Cataluña	19.0%	19.0%	16.9%	16.7%
10. Extremadura	1.8%	2.2%	2.6%	2.2%
11. Galicia	5.9%	6.1%	9.1%	6.5%
12. Madrid	14.8%	12.2%	12.4%	8.9%
13. Murcia	2.5%	2.4%	2.4%	1.4%
14. Navarra	1.7%	1.4%	1.4%	2.7%
15. Rioja	0.8%	0.7%	0.7%	1.7%
16. Valencia	9.8%	11.1%	9.9%	8.0%
17. País Vasco	7.2%	6.6%	5.8%	7.5%

Table 2: Long-term accumulated elasticities with respect to public infrastructure installed in the region and elsewhere

	Private Capital elasticities with respect to public infrastructure …		Employment elasticities with respect to public infrastructure …		Output elasticities with respect to public infrastructure …	
	in the region	elsewhere	in the region	elsewhere	in the region	elsewhere
Spain	0.270		0.414		0.523	
1. Andalucía	0.117	0.189	0.324	0.071	0.251	0.485
2. Aragón	0.047	0.394	0.189	0.040	0.155	0.197
3. Asturias	-0.627	0.198	-0.759	-0.048	-0.364	0.016
4. Baleares	0.782	-0.138	0.841	0.001	0.583	0.261
5. Castilla León	-0.025	0.220	0.183	-0.234	0.604	0.041
6. Castilla La Mancha	0.171	0.044	0.056	-0.700	0.443	0.201
7. Canarias	0.406	0.407	1.421	0.227	0.452	0.293
8. Cantabria	-0.406	0.236	-0.111	0.626	0.354	0.293
9. Cataluña	0.211	0.222	-0.163	0.006	0.116	0.164
10. Extremadura	0.776	-0.376	-0.329	-0.050	-0.263	-0.151
11. Galicia	-0.113	0.296	-0.106	-0.046	-0.232	0.496
12. Madrid	0.538	0.617	0.271	0.175	0.475	0.187
13. Murcia	0.160	0.329	0.571	0.230	0.341	0.397
14. Navarra	-0.220	0.173	0.068	0.012	-0.118	0.173
15. Rioja	0.034	0.603	0.132	0.725	0.032	0.237
16. Valencia	0.227	0.353	0.158	0.217	0.216	0.415
17. País Vasco	0.750	0.660	0.821	0.477	0.600	0.851

Table 3: Regional effects of public infrastructure on private capital

	Marginal Products with respect to public infrastructure …		Marginal Products	
	in the region (1)	elsewhere (2)	Total (3)=(1+2)	Regional distribution
1. Andalucía	0.208	0.337	0.545	8.3%
2. Aragón	0.020	0.166	0.186	2.8%
3. Asturias	-0.230	0.073	-0.157	-2.4%
4. Baleares	0.259	-0.045	0.214	3.3%
5. Castilla León	-0.021	0.188	0.167	2.5%
6. Castilla La Mancha	0.091	0.024	0.115	1.7%
7. Canarias	0.182	0.183	0.365	5.6%
8. Cantabria	-0.077	0.045	-0.032	-0.5%
9. Cataluña	0.497	0.523	1.020	15.5%
10. Extremadura	0.220	-0.105	0.115	1.8%
11. Galicia	-0.087	0.227	0.140	2.1%
12. Madrid	0.830	0.952	1.782	27.2%
13. Murcia	0.051	0.105	0.156	2.4%
14. Navarra	-0.039	0.031	-0.008	-0.1%
15. Rioja	0.003	0.054	0.057	0.9%
16. Valencia	0.332	0.518	0.850	13.0%
17. País Vasco	0.553	0.487	1.040	15.9%
Total all regions	2.794	3.762	6.556	100.0%

Table 4: Regional effects of public infrastructure on employment

	Marginal Products with respect to public infrastructure …		Marginal Products	
	in the region (1)	elsewhere (2)	Total (3)=(1+2)	Regional distribution
1. Andalucía	7.04	1.56	8.61	23.1%
2. Aragón	0.96	0.17	1.13	3.0%
3. Asturias	-3.22	-0.17	-3.39	-9.2%
4. Baleares	2.52	0.00	2.52	6.9%
5. Castilla León	1.83	-2.35	-0.52	-1.4%
6. Castilla La Mancha	0.35	-4.43	-4.09	-11.0%
7. Canarias	7.82	1.48	9.30	25.2%
8. Cantabria	-0.26	1.30	1.04	2.9%
9. Cataluña	-4.26	0.17	-4.09	-11.1%
10. Extremadura	-1.22	-0.17	-1.39	-3.6%
11. Galicia	-1.30	-0.61	-1.91	-5.1%
12. Madrid	5.39	3.48	8.87	23.9%
13. Murcia	2.17	0.87	3.04	8.3%
14. Navarra	0.17	0.03	0.20	0.4%
15. Rioja	0.17	0.78	0.96	2.5%
16. Valencia	2.43	3.39	5.82	15.6%
17. País Vasco	6.95	4.00	10.95	29.7%
Total all regions	27.56	9.51	37.05	100.0%

Table 5: Regional effects of public infrastructure on output

	Marginal Products with respect to public infrastructure …		Marginal Products	
	in the region (1)	elsewhere (2)	Total (3)=(1+2)	Regional distribution
1. Andalucía	0.187	0.362	0.549	17.7%
2. Aragón	0.030	0.037	0.067	2.2%
3. Asturias	-0.054	0.002	-0.052	-1.7%
4. Baleares	0.078	0.035	0.113	3.6%
5. Castilla León	0.206	0.014	0.220	7.1%
6. Castilla La Mancha	0.091	0.041	0.132	4.3%
7. Canarias	0.091	0.059	0.150	4.8%
8. Cantabria	0.026	0.022	0.048	1.5%
9. Cataluña	0.122	0.171	0.293	9.5%
10. Extremadura	-0.028	-0.016	-0.044	-1.4%
11. Galicia	-0.072	0.154	0.082	2.6%
12. Madrid	0.402	0.158	0.560	18.1%
13. Murcia	0.046	0.054	0.100	3.2%
14. Navarra	-0.011	0.016	0.005	0.2%
15. Rioja	0.001	0.011	0.012	0.4%
16. Valencia	0.119	0.228	0.347	11.2%
17. País Vasco	0.214	0.304	0.518	16.7%
Total all regions	1.447	1.651	3.098	100.0%

Table 6: On the effects of public infrastructure relative to the region's share of the private variables [(*)]

	Private Capital		Private Employment		Private Output	
	% of effects / % of regional private capital	% of effects / % of regional public infrastructure	% of effects / % of regional private employment	% of effects / % of regional public infrastructure	% of effects / % of regional private output	% of effects / % of regional public infrastructure
1. Andalucía	0.61	0.58	1.63	1.60	1.33	1.23
2. Aragón	0.82	0.62	0.88	0.67	0.65	0.48
3. Asturias	-	-	-	-	-	-
4. Baleares	1.32	2.35	3.64	4.93	1.64	2.57
5. Castilla León	0.37	0.27	-	-	1.13	0.76
6. Castilla La Mancha	0.43	0.32	-	-	1.16	0.81
7. Canarias	1.70	1.70	7.41	7.73	1..37	1.46
8. Cantabria	-	-	2.07	1.70	1.07	0.88
9. Cataluña	0.82	0.93	-	-	0.50	0.57
10. Extremadura	0.81	0.82	-	-	-	-
11. Galicia	0.34	0.32	-	-	0.44	0.40
12. Madrid	2.23	3.06	1.92	2.68	1.22	2.03
13. Murcia	1.00	1.71	3.46	5.93	1.28	2.29
14. Navarra	-	-	0.29	0.15	0.12	0.07
15. Rioja	1.28	0.52	3.57	1.47	0.50	0.23
16. Valencia	1.17	1.63	1.58	1.95	1.14	1.40
17. País Vasco	2.41	2.12	5.12	3.96	2.32	2.23

[(*)] Values greater than one reflect effects proportionately stronger than the region's size while the sign – identifies negative values.