The Spanish regions growth:
A story of infrastructure capital misallocation

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December 21, 2020

1.Introduction

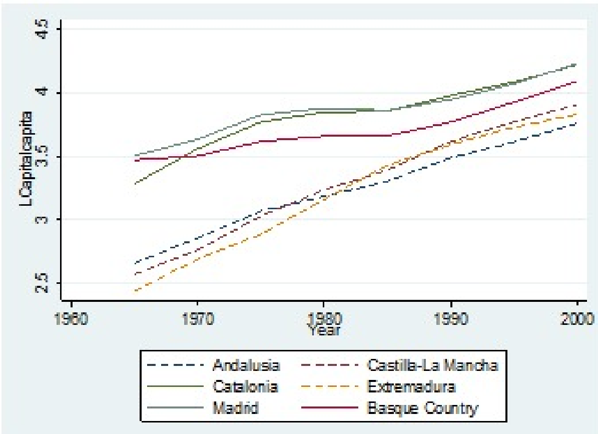
In the last years, a new social and political movement has appeared in Spain: “el movimiento por la España vaciada”; It is a movement which looks for the defence of the most rural areas by asking policies that encourage the economic development in those regions and stop the demographic decrease there. In other words, this heterogeneous and decentralized movement asks for reducing the economic gap between the richest and most urban regions and the poorest and most rural ones.Although these groups request for a lot of different economic policies, the most common claim of them is about investment in public infrastructures, like better roads, highways, railways and ports. Thus that, it would be interesting to analyse what effect public investments in infrastructures have had in the economic growth of the Spanish regions and in their process of convergence in the last decades. That is the propose of this paper.

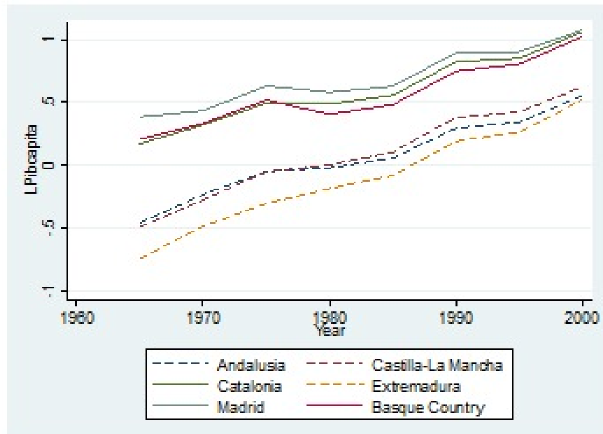
If we watch the top 4 poorest regions in 1930, at the end of the Alfonso XIII Reign, before the II Republic, and then we compare with the top 4 in 2015, we will find three regions in both years: Extremadura, Andalusia, and Castilla-La Mancha. If we repeat the same exercise with the top 4 richest, we will see a similar result; in this case, also 3 of the 4 richest regions in 1930 remains as the richest ones in 2015: Madrid, Catalonia, Basque Country. So, we could affirm that the haves follow be rich and the have-nots follow be poor; that would be a very simplistic conclusion. If we decide to do a deeper analysis, the question we have to wonder is, there have been convergence? And then, we will answer: yes, but no too much.

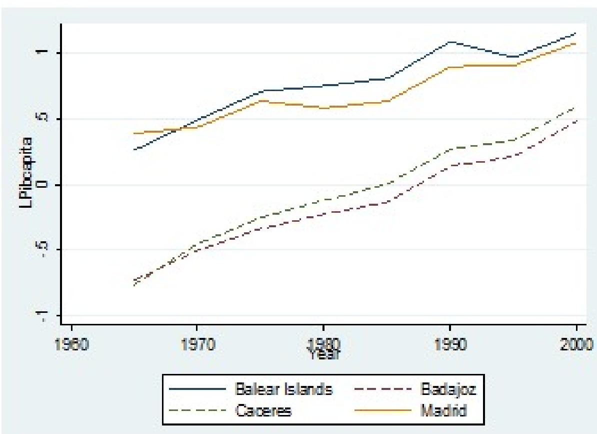
According with the conclusions of the Solow model, the poor countries should catch up the riches by capital accumulation given the decreasing marginal returns law. Taking the richest region and the poorest one in 1930 and in 2015, Madrid and Extremadura respectively, and calculating the ratios between their GDP per capita, we find that in 1930 the GDP per capita of Extremadura was just a 27% the one of Madrid, whereas in 2015 it was above 50% of the GDP per capita of Madrid.

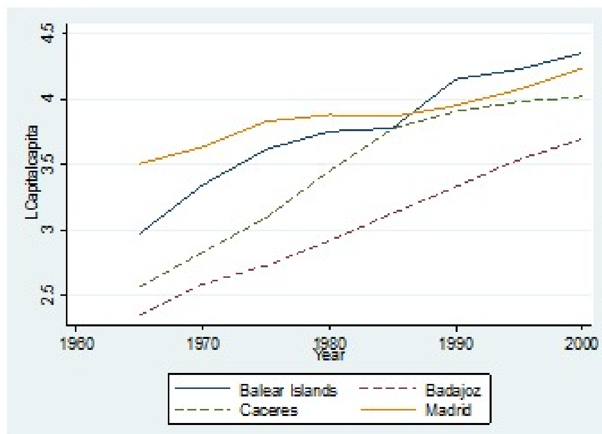
The literature points that fact, the Spanish regions have taken a convergence process but not too big. That is the conclusion of Sergio Puente (2017), for instance, who studied the Comunidades Autonomas convergence between 1980 and 2015. He also researches which factors were decisive in that convergence process, and comes to the conclusion that a bigger increase in productivity of the poorest regions explains their convergence toward the richest; that increase is driven in turn mostly by a bigger private capital accumulation of the poor regions Indeed, as we can observe in the Graphic 1, the capital per capita in the traditional poorest regions grew more than the one of the tradition richest regions. We can also see in Graphic 2 the income per capita in the poorest regions grew faster in that period.However, by compering both graphics, we see that the differences in the GDP per capita growth are smaller than in the capital growth.

If we focus in provinces instead of Comunidades Autónomas, we get the same conclusion. Graphic 3 and Graphic 4 show us that the catch-up process is stronger in capital per capita than in GDP per capita. Traditionally in Spain, the south regions have been poorest than the north ones, if we compare their means of GDP per capita growth, capital per capita growth, and infrastructures capital per capita growth, as we do in Table 1, we arrive again to that result: making some calculus, we watch that the capital per capita and infrastructures capital per capita growth on average were 10.49% and 12.35% respectively lager in the South provinces than in the North ones; however, the difference in GDP per capita growth between them was on average just the 5´35%.









2. A Growth Model

We depart our analysis from a common Solow model, where we have introduces public infrastructures:

$$Y = A(K^{\alpha}T^{\beta}L^{1-\alpha-\beta}) \tag{1}$$

In per capita terms and with logarithms such that:

$$\frac{Y}{L} = A(\frac{K}{L})^{\alpha}(\frac{T}{L})^{\beta} = Ak^{\alpha}t^{\beta} \tag{2}$$

$$y = ln(A) + \alpha ln(k) + \beta lnt \tag{3}$$

So, firstly, we are going to use this model in order to regress the impact of the total capital per capital of infrastructures on the income of of each Spanish province by year. Following that, we will separate the infrastructures into 6 categories: roads, railways, hydroelectric infrastructures, ports, airports and urban infrastructures. Additionally, we will include some controls and province and year fixed effects.

$$y_{i,t} = \beta_0 + \beta_1 k_{i,t} + \beta_2 t_{i,t} + X'\gamma + \delta_i + \delta_t + u_{i,t} \tag{4}$$

$$y_{i,t} = \beta_0 + \beta_1 k_{i,t} + \beta_2 t_{i,t} + X'\gamma + \delta_i + \delta_t + u_{i,t} \tag{5}$$

$$\begin{split} y_{i,t} = \beta_0 + \beta_1 k_{i,t} + \alpha * road_{i,t} + \rho * rail_{i,t} + \eta * hydroelectric_{i,t} + \theta * airport_{i,t} \\ + \phi * port_{i,t} + \nu * urban_{i,t} + X'\gamma + \delta_i + \delta_t + u_{i,t} \end{split} \tag{6}$$

Data

The first challenge I have faced in this project has been the data collection. As I am interested in studying the long run economic growth of regions, and not a country, there is not too much data. Fortunately, there is a paper (Alcaide, 2003) which contains the main macroeconomic variables for each Spanish region and provinces since 1930 to 2000. GDP data and labour force by sector (agriculture, industry, construction and service) have been taken from there.

Concerning to capital, Fundación BBVA offers a very completed data, since 1964 to 2016, where capital is presented by regions, economics sectors and by its nature (houses, infrastructures, machinery, intellectual property products. . .). From here, the total capital, the capital in total building no houses, and the capital in different kinds of that buildings: roads, railways, airports, ports, hydroelectric infrastructures, urban ones, and others. All that data was taken by province and year. Population by province was taken from the national survey institution (INE). In addition, I added the extension in kilometers of each province.

All the information was putting in a panel data by year (1965, 1970, 1975,1980, 1990, 1995, 2000) and province. As you may have realised, although in the introduction I have talked about the regions of Spain (Comunidades Autónomas), I will make my analysis taken account a smaller territory unit: the provinces. The reason for that is just to have a bigger sample.

Also, some concerns must be said regarding the variables. Total infrastructures is obtained by subtracting other buildings from buildings no houses; and capital not infrastructures, created by subtracting total infrastructures from total capital. Moreover, I computed the main variables (GDP, total capital and infrastructures) in per capita terms. I also computed the population density, the percentage of labour force of each sector, and a dummy variable which takes the value 1 for the provinces that contain the capital city of their region. The variables were computed in logarithmic terms too.

Results

Our estimations are shown in Table 1 and Table 2. We can observe how our main variables, infrastructure capital per capita (*Linfracaptial*) and the ones for each type of infrastructure, display very different coefficients and significance depending on the model. Regarding the aggregated infrastructures, they are initially insignificant, but they a significant a positive effect when when introduce interactions (2) with the population density and with a dummy which reflects if the province hold the capital city of the region; its coefficient is also reduced when we introduces controls for the sectors (3). From this results, we can interpret that the infrastructures have a different marginal effects across the provinces depending, at least, on the population density, the capital status, and the importance of the economic sectors.

If we separate the infrastructure capital stock into different categories we can arrive to the same conclusion than before. In this case, we firstly regress a simple OLS model (1) without provinces fixed effects, and then we introduce them (2 and followers), losing by that the significance of airports hydroelectric infrastructure, and urban ones. When economic sector are taken account (5), rails turn into significant if we also consider the population density, while roads become insignificant; ports get a positive and significant coefficient if we restrict the regression to the coastal provinces. Therefore, we observe that the coefficients of those types of infrastructures change depending on some characteristics of the provinces. In addition, from this regression we can reach to another conclusion: the different kind of infrastructures have different marginal effects on the income per capita.

Both ideas allow us to underline that there have been misallocation of the infrastructures investments in Spain in two dimensions: misallocation among provinces, and misallocantion among the different kind of infrastructures.

Due the data limitations (we have only date about 8 years for each province), we cannot estimate properly the magnitude of these misallocations, but in the next sections we will study how to do it if we had a suitable data set.

Misallocation models

0.1 Static model

Following Restuccia and Santaeulàlia (2017), we may calculate the outcome loss produced by the misallocation of resources through these steps:

Table 1: Aggregated Infrastructures

	(1)	(2)	(3)
LCapper2	0.307***	0.167***	0.135***
	(0.0326)	(0.0296)	(0.0302)
LInfracaptial	0.0254	0.0657***	0.0338*
	(0.0189)	(0.0163)	(0.0199)
densiinfra		-0.000000410***	-0.000000301***
		(5.71e-08)	(6.42e-08)
Capiininfra		-0.0548***	-0.0476***
		(0.0114)	(0.0129)
agriculture			0.162
			(0.124)
industry			0.496***
			(0.160)
construction			0.874***
			(0.286)
N	400	400	400
adj. R^2	0.984	0.988	0.989

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.010

Table 2: Separated Infrastructures

	(1)	(2)	(3)	(4)	(5)
LCapper2	0.600***	0.288***	0.205***	0.151***	0.207***
	(0.0321)	(0.0336)	(0.0294)	(0.0299)	(0.0423)
LRoadscapita	0.0288*	0.0415***	0.0242**	0.00794	0.0233
	(0.0157)	(0.0129)	(0.0111)	(0.0124)	(0.0216)
LHydraucapita	-0.0857***	-0.0146	-0.00880	-0.00688	0.00639
	(0.0124)	(0.0103)	(0.00899)	(0.00998)	(0.0148)
LRailwayscapita	0.00345	-0.00441	-0.00864	-0.0140**	-0.00365
	(0.00750)	(0.00713)	(0.00610)	(0.00669)	(0.00691)
LAerportcapita	-0.00594*	-0.00467	-0.00204	-0.000230	-0.00226
	(0.00333)	(0.00301)	(0.00244)	(0.00264)	(0.00493)
LPortcapita	-0.000212	-0.0251	-0.0218	-0.0165	0.0339*
	(0.00971)	(0.0184)	(0.0158)	(0.0146)	(0.0198)
LUrbancapita	0.0422**	0.00856	0.00652	0.00931	0.0267
	(0.0178)	(0.0123)	(0.0110)	(0.0104)	(0.0177)
Density			-0.00000137***	-0.00000106***	
			(0.000000164)	(0.000000143)	
agriculture				0.207*	0.397**
				(0.125)	(0.177)
industry				0.620***	0.986***
				(0.161)	(0.240)
construction				0.921***	0.891**
				(0.313)	(0.443)
N	400	400	400	400	184
adj. R^2	0.901	0.984	0.988	0.989	0.988

Standard errors in parentheses
* p¡0.10, ** p¡0.05, *** p¡0.010

1. Considering a setting of heterogeneous producer agents, which use one or more inputs, we compute the efficient allocation as the point where all the agents have the same marginal product for the input (inputs).

2. Once we have estimated the efficient output, we calculate the loss due to the misallocation by dividing the actual and observed output between the efficient one.

In our model,:

$$y_i = A_i k_i^{\alpha} t_i^{\beta} \tag{7}$$

$$y_{total} = \sum_{i=1}^{I} A_i k_i^{\alpha} t_i^{\beta} \tag{8}$$

where i ∈ I= 50 for the provinces, or I = 17 for the regions ("Comunidades Autónomas") Then, let's assume there is planner who decide all the investments on infrastructures in Spain, and who has a budget such as:

$$\Omega = \sum_{i=1}^{I} t_i \tag{9}$$

We would reach the efficient allocation in:

$$t_i = \frac{A_i}{\sum_{i=1}^{I} A_i} \Omega \tag{10}$$

However, we are interested on analyse the misallocation on a dual dimension, across provinces, but among different kind of infrastructures too. With this propose, we extend the restriction to the following:

$$\Omega = \sum_{i=1}^{I} t_i = \sum_{i=1}^{I} [c_{rd,i} * road_i + c_{rl,i} * rail_i + c_{h,i} * hydroelectric_i + c_{a,i} * airport_i + c_{p,i} * port_i + c_{u,i} *] \tag{11}$$

where the $c_{t,i}$ are the provincial costs of building the infrastructure t. And we obtain a different efficient condition which entails the equality of the marginal product of each kind of infrastructure of each province:

$$\begin{aligned} \Omega = \sum_{i=1}^{I} t_i = \sum_{i=1}^{I} [c_{rd,i} * road_i + c_{rl,i} * rail_i + c_{h,i} * hydroelectric_i \\ + c_{a,i} * airport_i + c_{p,i} * port_i + c_{u,i} * urban_i \end{aligned} \tag{12}$$

$$\frac{\partial y_i/\partial road_i}{c_{rd,i}} = \frac{\partial y_i/\partial rail_i}{c_{rl,i}} = \frac{\partial y_i/\partial hydroelectric_i}{c_{h,i}} = \frac{\partial y_i/\partial airport_i}{c_{a,i}} = \frac{\partial y_i/\partial port_i}{c_{p,i}} = \frac{\partial y_i/\partial urban_i}{c_{u,i}} \tag{13}$$

With this solution, the planner not only decide where to invest, in which province, but also how to invest, in which kind of infrastructure taking in consideration the particular characteristics of each provinces through its costs. Note that we are assuming all the types of infrastructures as perfect substitutes.

0.2 Network model

Another very interesting possibility is to approach the problem from a network point of view. Buy this way, we could take account the spillover effects of investing in one location over another linked location. This is what Fajgelbaun and Schaal (2020) study, focusing on the roads networks. They propose the following model:

$$W = \max_{I_{jk}} \max_{Q_{jk}^n} \max_{(c_k, D:j^n, L_j^n, V_j^n, X_j^n)} \sum_j \omega_j L_j U(c_j) \tag{14}$$

It consists in triple maximization problem: the allocation problem of consumption; a optimal flow problem , which looks for the gross flow, Q_{jk}, at the least-cost route at the considering congestion may happen; and the optimal network, I_{jk}, which regards the costs and gain of building the transport infrastructure. They also assume in this cases labor mobility, which has sense in national frameworks. They resume their results for the case of the Spanish roads in Figure1.

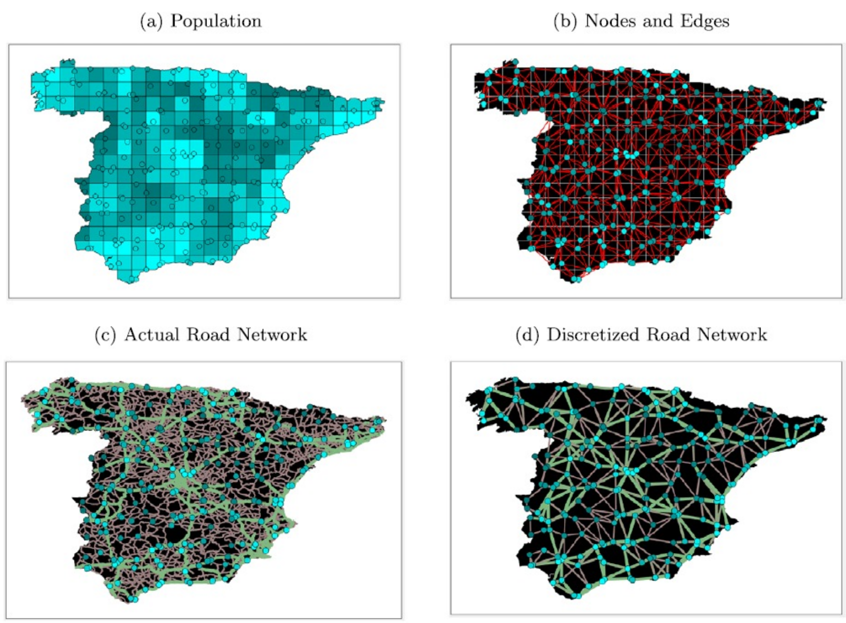


Figure 1: Taken from Fajgelbaun and Schaal (2020). On c) we can observe the actual network of Spanish , whereas d) shows the optimal net of roads they obtained.

Fajgelbaun and Schaal (2020) divide the roads into two categories: national roads (which includes highways) and non-national road; the latest ones are chipper to be built , but are more probably to get congested given they have less lanes. Hece, we could replicate the same exercises of optimization regarding as before the trade-off of building and using different kind of infrastructures, assuming again they are substitute. This assumption holds for the railways, the airports and ports, but not anymore for hydroelectric and urban infrastructures.

Figure 2: Taken from Observatorio del Ferrocarril en España (2018). Net of railways in Spain.

Conclusions

Gary Becker said: "Putting new infrastructure spending in depressed areas like Detroit might have a big stimulating effect since infrastructure building projects in these areas can utilize some of the considerable unemployed resources there. However, many of these areas are also declining because they have been producing goods and services that are not in great demand, and will not be in demand in the future. Therefore, the overall value added by improving their roads and other infrastructure is likely to be a lot less than if the new infrastructure were located in growing areas that might have relatively little unemployment, but do have great demand for more roads, schools, and other types of long-term infrastructure."

As we have seen, along the recent decades of the history of Spain, its provinces have followed a relative convergence process, where the poorest regions have shorted down their distance to the richest ones, but a slowly one. The inequalities between regions are still important in spite of the big increases in capital stoke, private and public, of the poor regions. In this paper we have tried to explain the reasons of that fact.

Firstly, we have found that infrastructure investment matters. In most of the previous models, the increase of the infrastructure stock is correlated with an increase of the income. We cannot claim technically causality anyway.

Secondly, we should remark that we have found differences in that hypothetical effect depending on other variables: density population and capital city. Because of that, we can defend that the increase on income produced by infrastructure investment is bigger in urban areas than in rural ones. That could explain the slowly convergence process by understanding that there have been misallocation of resources across provinces; because if not, their marginal product, i.e. their effect on the income would remain equal for all the provinces regardless of other characteristics. We also found that not all the infrastructures have the same effects apparently, and therefore we can claim misallocation among the different kind of infrastructures too.

As we cannot go forward given our data constraints, we have studied theoretically how we could calculate the magnitude of the misallocation and the output loss it drives.

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