R&D And Growth in the Spanish Regions: An Empirical Approximation

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Abstract

This paper intends to analyze some features about R&D activities in the recent past in Spain, at the national and regional level. The comparison of some R&D indicators from Spain and other developed countries suggests that Spain is lagging behind especially in terms of the allocation of resources to R&D from the business sector and also in generation of patents. As far as regional behavior is concerned, R&D is concentrated in several regions which are at a remarkable distance from the rest. Finally, we estimate a panel data model linking economic growth to R&D indicators and other variables for the Spanish regions over the years 1995-2008. Main results suggest that total R&D intensity has a positive impact on growth. When R&D is disaggregated according to the type of investor, business R&D has a positive and significant impact on growth. The impact of public and university R&D activities is not significant.

Keywords: Regional growth; Technology; R&D; Patents.

JEL: O40

1. Introduction

In the last 25 years numerous theoretical and empirical studies have highlighted the role of technology as a key factor in the growth process of countries and regions. Many of these contributions have been pursued within the framework of the New Growth Theory, built upon the research of prominent economists in the late 1980s and early 1990s.

Solow (1956) had already stressed the importance of technological change as a driving force of economic growth. His model, which rested on a production function which was concave in labor and capital, considered technological progress as exogenous and predicted that the economy would eventually reach a steady state in which the rate of growth of output per capita would be zero.

In endogenous growth models, instead, (Romer, 1986, 1990; Lucas, 1988; Barro, 1990; Rebelo, 1991), growth is generated within the own model. In contrast with neoclassical models, in this kind of settings the marginal productivity of one or some of the inputs is non decreasing and may bring about positive growth even in the steady state. In many of these models the ultimate force driving growth is somehow linked to technology, either embedded in labor (Lucas, 1988), considered as an increase in the number of available intermediate goods (Romer, 1990), or as an increase in the quality of these inputs (Grossman and Helpman, 1991; Aghion and Howitt, 1992).

Innovation and technology have thus acquired a central role not only within economic research, but also in the agenda of policymakers. There is a general consensus nowadays about the idea that R&D plays a crucial role as a determinant of the competitiveness of firms and of progress for countries and regions.

A country or region may increase technological capital in two main ways: innovating or imitating technology produced elsewhere. In the first scenario, there is an explicit and conscious investment of resources in R&D activities which gradually builds a stock of technological capital. In the second case, instead, typical in many developing countries, innovating is considered too expensive or even infeasible, due to the lack of the appropriate scientific personnel or infrastructure. Access to technological improvements in these cases is reached by means of imitating[1] or adapting products or processes which have been developed successfully by technological leaders[2]. During the second half of the 20th century, Spain acted basically as an imitator; importing intermediate goods of state of the art technology (see Sanchez-Robles, 2006). In the last decades, however, there is a general sentiment expressing that the country should be more active in generating R&D. The reasons are several: the intention to change the pattern of growth, the desire to compete in high value added goods, the awareness of the difficulties associated with cost competition with emerging countries and the implied necessity to emphasize product differentiation via quality, among others.

In the last decade, the country has made an important effort to close the technological gap with other European countries. Resource allocation to R&D, though, has not been homogeneous among Spanish regions. There are some regions (Madrid, Cataluña or País Vasco), which devote many more resources to innovation than others.
Since, from the theoretical point of view, technological progress is one of the reasons behind increases in per capita income, it may be interesting to analyze if there is a positive correlation between R&D investment and output growth in the sample encompassed by Spanish regions. If this is the case, it would be reasonable for policymakers at different levels of administration to generate incentives to R&D as a way to foster growth in their correspondent areas. If the correlation is not detected, however, the efficacy of some policies intended to enhance innovation would be more questionable.

Some papers have already stressed the connection between technology (sometimes understood as human capital) and growth for the case of Spanish regions (among others, Cancelo, Diaz, & Guisán, 1998; Maudos, Pastor, & Serrano, 2000; Pedraja, Salinas, & Salinas, 2002; Boscá, Escribá, & Murgui, 2004; Pablo-Romero, & Gómez-Calero, 2008; Casares et al., 2012; Bengoa-Calvo, & Pérez, 2011). The goal of this paper is to continue in this direction by means of analyzing some R&D indicators and by estimating a panel data model for the 1995-2007 period; more in particular, we want to assess the impact of R&D, disaggregated by type of investors, on GDP growth over the aforementioned period. In this regard, our work is similar in some aspects to Bengoa-Calvo, & Pérez (2011), but our approach focus to a greater extent in the impact of R&D indicators, and we work with alternative data basis, variables and temporal horizon.

2. Some Stylized Facts on R&D in Spain and Its Regions

2.1. R&D in Spain

Generally speaking, countries enjoying higher levels of per capita income devote larger amounts of resources to R&D investment. Spain allocates to innovation a smaller proportion of GDP that the EU average, although it is true that this figure has increased over time. R&D expenditure as a percentage of GDP in Spain has grown from 0.4 in 1981 to 1.38% en 2009; the number of researchers per thousand employees has increased from 1.6 per in 1981 to 6.98 in 2009 (OCDE, 2012).

Table 1 provides a first approximation to this issue and summarizes some indicators on R&D for Spain, Japan, USA, EU and OECD.

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[1] Imitation of foreign technology may be accomplished by various channels. The main ones are imports of intermediate goods and foreign direct investment (FDI). In these cases, in turn, technology is embedded in the products or processes. (See Coe and Helpman, 1995; Lichtenberg and Van Pottelsberghe de la Potterie, 1998; Van Pottelsberghe de la Potterie and Lichtenberg, 2001; Coe, Helpman and Hoffmaister, 2009; Zhu and Jeon, 2007.) There are also other, more informal, channels of (non embedded) technological diffusion, as internet, scientific literature or international conferences (Tang and Koveos, 2008).

[2] In fact, it could be argued that most nations, even developed, have a mix of both practices: they innovate in some areas and adopt foreign technology in others. What varies is the composition of the mix. There are countries at the technological frontier in many areas (USA, Japan, Germany) and others that are mostly imitators.

Table 1. Indicators of R&D.

	R&D Expenditure (% GDP)	R&D Expenditure per capita (2005 US$ PPP)	Researchers (x1000 hab.)	Scientific publications (x million hab.)	Scientific publications (x1000 researchers)	Patent Applications (x million hab.)
Spain	1.38	374.6	6.98	422 (2005)	220 (2005)	27.2
EU-27	1.92	525.0	6.90	477 (2005)	200 (2005)	102.5
OECD	2.4	709.9	7.56 (2007)	..	..	87.3
Japan	3.36	986.6	10.36	..	..	135.6
USA	2.9	1192.1	9.53 (2007)	..	..	89.1

Notes: figures correspond to 2009 except for the number of researchers in Japan and USA (2007) and papers published (2005). Source: OECD, Gámir and Durá (2010)

In 2009 (last year for which data are available), Spain devoted to total expenditure in R&D 1.38% of GDP, 0.54% less than the EU-27, almost one point below the OECD and nearly two points below Japan. Expenditure per capita in Spain is also smaller than in the rest of the countries or areas considered. Relative to Japan or the USA; Spanish R&D expenditure per capita accounts for 1-to-3 and 1-to-4, respectively. The number of researchers (expressed in full-time equivalent, FTE) is also smaller in Spain than in the OECD, Japan and the USA, although here the difference is minor. If we compare outputs of the innovation process, instead of inputs, we see that the number of scientific publications per million inhabitants in Spain in 2005 was 422, 88.5% of the European average. The comparison is even more favorable for Spain if we compare articles per thousand researchers; the figure for Spain in 2005 was 220, 110% of the European average. As it is apparent from Table 1, the largest differences lie in the number of patents, where Spain is well behind EU and OECD. These numbers suggest a specific model of R&D generation, if we group agents carrying out R&D in three usual categories: public sector, universities and firms[3]. Generally speaking, the business sector is more oriented towards applied research, which results in patents, whereas universities and public sector institutions direct their R&D towards basic research, diffused by means of scientific publications. According to these data, therefore, Spain is intensive in public R&D (Gámir and Durá, 2010).

Table 2 confirms this idea. It details the share in total R&D expenditure by type of investor for Spain, EU-27, OECD, USA and Japan over 1995-2009.

Table 2. Participation in total R&D expenditure by type of investor

	Average 1995-2001					Average 2002-2009				
	SPA	EU-27	OECD	USA	JPN	SPA	EU-27	OECD	USA	JPN
Firms	51.8	63.6	70.9	76.3	75.0	54.6	63.6	70.8	74.5	78.1
Government	17.0	15.3	12.8	11.9	9.5	17.0	13.5	11.8	12.0	8.8
University	31.2	21.1	16.2	11.8	15.5	28.4	22.8	17.4	13.5	13.1

Source: OECD various years.

In the first sub period, 1995-2001, only 51.8% of total expenditure in R&D in Spain corresponds to the business sector. This figure is around 75% in USA and Japan, 71% in OECD and 63.6% in EU. In parallel, the share of the public sector and the universities are two and ten points larger than those of EU, respectively. The difference of these shares with regard to the rest of the sample is of course larger. For the second sub period, 2002-2009, the share of the business sector for Spain has increased slightly, while that of universities has decreased in the same proportion. The relative participation of universities has increased somehow for EU, USA and OECD in this second sub period. Japan, OECD and EU have decreased their public sector shares, while USA has increased theirs. Thus, nor the composition neither the behavior over time of relative shares is similar for Spain and the rest of countries considered.

Table 3: Patent Applications.

	Average 1995-2001					Average 2002-2009				
	SPA	EU-27	OECD	USA	JPN	SPA	EU-27	OECD	USA	JPN
Patents per million inhabitants	14.8	85.7	78.6	94.6	126.9	27.2	111.7	100.4	109.4	164.2

Source: OECD various years.

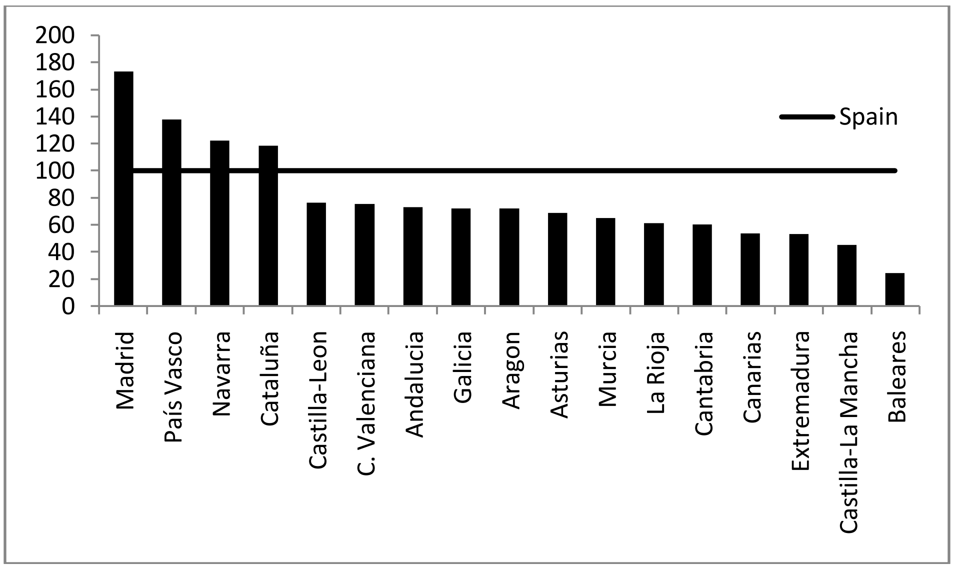
[3] The fourth, private nonprofit institutions, is less relevant in Spain. In this paper its contribution is included in that of firms.

Data on patents (Table 3) reinforce these considerations. During 1995-2001 Spain produced 14.8 patents per million inhabitants, which is tantamount to 17% of the result for EU, 19% of OECD, 16% of USA and 12% of Japan. For the second sub period Spain almost doubles the number, and converges partially to the other members of the sample, registering around 25% of the figures of EU, USA and OECD and 17% of Japan. Some partial conclusions may be summarized at this point. Spain devotes to R&D a smaller percentage of GDP than other advanced countries; in terms of relative composition, the share of business expenditure is smaller for Spain; this particular pattern partially explains the lagging position of Spain in terms of generation of patents.

2.2. Regional Performance of R&D

Next we discuss some data on Spanish regional distribution of R&D over 1995-2008. Figure 1 shows total expenditure in R&D as a percentage of GDP.

Figure 1. Regional R&D expenditure. Average 1995-2009. Index, Spain=100



Source: OECD various years.

As it can be noticed in the figure, the dispersion between regions is high (the standard deviation is 36.45). Madrid exhibits the largest indicator, 173% of the national average. It is followed by País Vasco, Navarra and Cataluña, in this order. The difference between Madrid and the País Vasco is remarkable, 34 points. País Vasco and Navarra differ in 15 points, which is also noticeable. Cataluña is close to Navarra. These four regions are well above the national average. The difference between Cataluña and the next in the ranking, Castilla-León, is 41 points. There is a group of 9 regions with indicators in the range of 60-70% of the national average. Finally, the regions registering the smallest values are Canarias, Extremadura, Castilla La Mancha and Baleares, these last two are below 50% of the national average. We could speak, therefore, of three categories: the leaders, with Madrid in the first position, the intermediate regions and the laggards. This picture is similar to that of 15 years ago (Buesa, 1998).

Table 4 disaggregates R&D expenditure by type of investors. The business sector share is relatively high in País Vasco, Navarra, Cataluña, La Rioja and Madrid, and rather small in Canarias, Baleares and Extremadura. The case of La Rioja is remarkable. Innovation in the region has been very active in the last few years[4], especially in the areas of chemistry and nanotechnology[5]. The university share is comparatively large in Extremadura, Baleares, Canarias and Comunidad Valenciana, whereas the public sector share dominates in Extremadura, Baleares, Madrid and Canarias. The comparison between Tables 4 and 5 suggests that the regions with higher expenditure in R&D are also those in which the business sector share is higher.

[4] La Rioja has implemented a three stages R&D program, with Phase I (1999-2002), Phase II (2003-2007) and Phase III (2008-2011).

[5] Universidad de La Rioja leads the Nanoret Project, in association with Universidad Pública de Navarra, the Institut National des Sciences Appliquées de Toulouse and two firms, Avanzare, (Spanish) and Nanomeps (French).

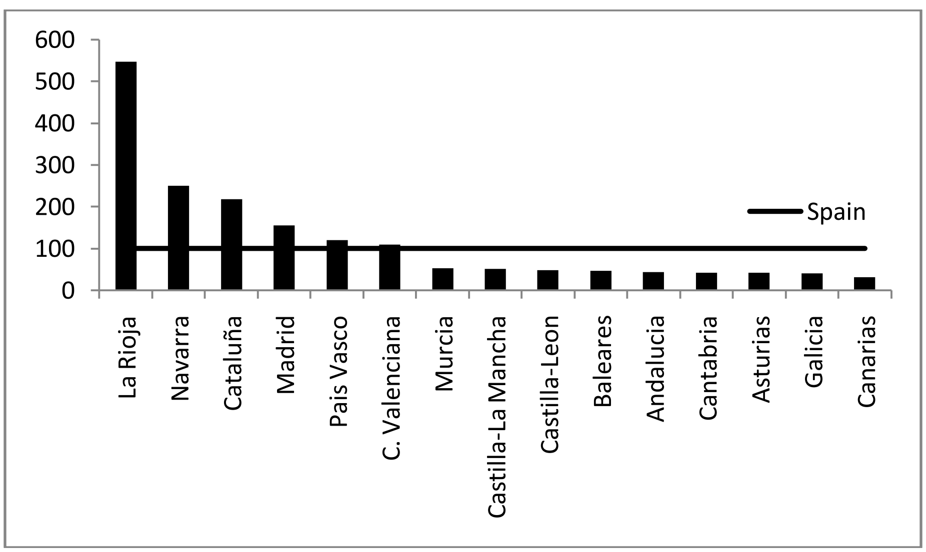
Table 4. Share of R&D expenditure, by type of investor. Average 1995-2008.
In percentage of total regional R&D expenditure

	R&D expenditure Government sector	R&D expenditure Tertiary education	R&D expenditure Business sector
Andalucía	20,9	46,1	33,1
Aragón	18,2	26,0	55,8
Asturias	16,6	41,3	42,1
Baleares	23,1	59,1	17,9
Canarias	25,8	54,0	20,3
Cantabria	20,5	41,2	38,2
Castilla-La Mancha	13,2	34,9	51,9
Castilla-León	8,5	41,2	50,3
Cataluña	10,2	24,3	65,6
Comunidad Valenciana	12,1	52,0	35,9
Extremadura	24,5	58,3	17,4
Galicia	16,1	44,9	39,0
La Rioja	13,6	24,2	62,1
Madrid	25,9	17,1	57,0
Murcia	18,6	38,9	42,5
Navarra	5,1	29,1	65,8
País Vasco	3,6	17,6	78,8
Spain	16,6	29,4	54,0

Source: OECD various years.

Figure 2 summarizes some data on patents requested by the Spanish regions over 1995-2008[6]. In accordance with their high shares of business expenditure in total R&D, La Rioja, Navarra, Cataluña, Madrid and País Vasco lead the ranking.

Figure 2. Patent Applications per million of inhabitants. Average 1995-2008.
Index, Spain=100.



Source: OECD various years.

The dispersion is still higher in this case than for expenditure in R&D. Navarra, Cataluña, Madrid and the País Vasco exhibit figures between 250% and 120% of the Spanish average (La Rioja shows an outstanding behavior in terms of patents, about 550% of the national average). Valencia is now in a more prominent place in the ranking, achieving almost 110% of the national average. Again, we can find a large group of regions with values of the indicator close to 50% of the average. The analysis of the regions, therefore, results in a multi-polar scenario. There is a group of regions with high levels of expenditure in R&D, remarkable business shares and sound results as far as patents are considered.

[6] Data were not available for Extremadura and Aragón.

There is a second, rather large group, with medium values of the indicators and well below the leaders. The regional picture differs from the national: the role of public expenditure is not so prevalent in the regions as in the nation, and some regions stand out for their share of business in R&D expenditure, which has yield fruits in terms of patterns[7].

3. Theoretical Background

Next we present the theoretical framework upon which our empirical analysis is based.
Following Hall et al. (2009), our starting point is a Cobb Douglas production function, augmented with technological capital:

$$Y_{it} = AL_{it}^{\alpha} K_{it}^{\beta} R_{it}^{\gamma} \tag{1}$$

where Y is a measure of output, L of labor, K of physical capital and R of technological capital. α, β and γ are the elasticity of output with respect to L, K and R, respectively**.** i indexes regions and t time.

If we take logs and differentiate with respect to time in equation 1 we have the expression in terms of rates of growth, which is more convenient for the empirical analysis. Adding an error term provides an equation (2) that can be tested by econometric procedures:

$$\Delta Y_{it} = \theta + \alpha \Delta L_{it} + \beta \Delta K_{it} + \gamma \Delta R_{it} + \varepsilon_{it} \tag{2}$$

4. Empirical Analysis

4.1. Data

We use real GDP growth rate (GDP per capita growth rate) for the 17 Spanish regions over the period 1995-2008 as the dependent variable.

This variable is constructed from the GDP (GDP per capita) series –in constant Euros of 2000–, available from the Regional Statistics Database (OECD). Employment and population data come as well from the OECD's Regional Statistics Database. The data on capital stock and investment are taken from the *Fundación BBVA* and *Instituto Valenciano de Investigaciones Económicas (IVIE)*. Relative to the R&D variables employed in this paper, two databases have been used. R&D expenditures performed by the business, government and tertiary education sectors (as % of GDP), and patent applications (per million inhabitants) have been constructed using data from the OECD's Regional Statistics Database. Data on the number of researchers employed in the business, government and tertiary education sectors, come from the Spanish Statistical Office *(INE)*.

4.2. Results

We estimate the relationship between several R&D indicators and economic growth for a panel data for the 17 Spanish regions[8] over the period 1995-2008. The starting year of our study, 1995, is motivated by the availability of R&D expenditures and researchers data for the whole set of regions analyzed.

The empirical equation to be estimated is similar to equation 2 above and is defined as follows:

$$Growth_{it} = \alpha + \beta_1 ln(GDP_{it-1}) + \beta_2 ln(I_{it}) + \beta_3 ln(L_{it}) + \beta_4 ln(R\&D_{it}) + u_{it} \tag{3}$$

where $Growth_{it}$ is the real GDP rate of growth, GDP_{it-1} is the real GDP in the previous year. This variable has been included to capture the conditional beta convergence. I_{it} is the total investment measured as a fraction of the GDP. L_{it} is the participation of employment over total population and, $R\&D_{it}$ represents the several regional R&D variables considered in each case –expenditures, researchers and patent applications–. u_{it} represents the classical disturbance term. Sub-index *i* stands for the 17 regions and *t* captures the temporal horizon. A number of techniques have been used. We begin by estimating equation (3) using the Least Squares Dummy Variable method (LSDV or fixed effects). The results set out in table 5 indicate that for the sample considered GDP growth rates are negatively related to the level of GDP in the previous period, capturing the process of conditional beta convergence among Spanish regions. Estimates are in line to those presented in Cuadrado-Roura (2001) for the EU regions. At the same time, the GDP growth rate is positively related to the investment-GDP and the employment-population ratios.

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[7] See Buesa et al. (2006) for a detailed analysis of the different systems of innovation for each region.
[8] Autonomous cities –Ceuta and Melilla–, are excluded from the sample due to the lack of data.

Table 5. R&D and Growth, Spanish Regions, 1995-2008 (LSDV-FE).

Estimation method: Least Squares Dummy Variables (Fixed Effects).
Dependent Variable: Real GDP Growth Rate.

	(1)	(2)	(3)	(4)	(5)
$GDP_{(t-1)}$	-0.257 ***	-0.265 ***	-0,259 ***	-0.260 ***	-0.238 ***
	(0.018)	(0.023)	(0.013)	(0.011)	(0.017)
Investment	0.022 **	0.018 **	0.023 **	0.023 **	0.028 **
	(0.011)	(0.009)	(0.010)	(0.009)	(0.012)
Employment	0,264 ***	0.270 ***	0.265 ***	0.254 ***	0.229 ***
	(0.024)	(0.029)	(0.015)	(0.010)	(0.027)
$R\&D_{total}$ Expenditure	0.013 ***				
	(0.003)				
$R\&D_{gov}$ Expenditure		0.002			
		(0.003)			
$R\&D_{univ}$ Expenditure		0.001			
		(0.005)			
$R\&D_{bus}$ Expenditure		0.008 ***			
		(0.003)			
$R\&D_{total}$ Researchers			0.008		
			(0.006)		
$R\&D_{gov}$ Researchers				-0.001	
				(0.001)	
$R\&D_{univ}$ Researchers				-0.001	
				(0.002)	
$R\&D_{bus}$ Researchers				0.006 *	
				(0.003)	
Patent applications					0.005 ***
					(0.001)
# Observations	204	204	221	221	179
Adjusted R^2	0.402	0.419	0.502	0.512	0.385
Hausman Test for R. E.	125.8 ***	126.6 ***	199.9 ***	166.1 ***	122.0 ***

Source: own elaboration

Notes: ***, ** and * represent significance at the 1%, 5% and 10% level. Robust standard errors in parenthesis. All explanatory variables are in natural logarithms. The Hausman statistic rejects the null hypothesis of no correlation between unobserved individual effects and explanatory variables in all cases. Regional and time fixed effects are considered.

When it comes to analyze the contribution of R&D activities to economic growth, the evidence shown in table 6 is mixed and depends on the proxies used. Columns 1 and 2 introduce the R&D intensities, this is, R&D expenditure-to-GDP ratios. Column 1 considers total expenditure while column 2 disaggregates this R&D expenditure in business, government and tertiary education sectors. Results regarding these variables suggest that total expenditure is positively and significantly correlated with the GDP growth rate. Notwithstanding, if sectoral R&D intensities are taken into account the outcomes of the estimation are different. On one hand, the R&D expenditure –as a GDP fraction– performed by the government and the tertiary education sectors are not statistically significant, although positive. On the other hand, R&D expenditure performed by the business sector is positively related to the economic growth rate and also significant at the 1% level.

Columns 3 and 4 tell more or less the same story. In these cases the fraction of researchers held by the business, government and tertiary education sectors over total employment are used as proxies for R&D activities. Only researchers employed by the business sector contribute marginally –statistically significant at the 10% level–, to economic growth. In the first four columns of table 1 input variables have been used to measure R&D activities, either expenditure or researchers. However, in terms of economic growth, what it seems more important is the results of those R&D activities, this is, the output. A number of output measures are used in the literature, as the proportion of development projects that have had commercial success, the percentage of sales of new products, profitability relative to spending, papers published, patents received, patent citations, or awards won among others (Gold, 1989; Loch, & Tapper, 2002; Kim, & Oh, 2002; Villaverde, & Maza, 2010).

Most of the variables mentioned above are proposed at the micro level. From a macroeconomic point of view patent applications and patents received have been widely used (Giriliches, 1984; Mansfield, 1986; Hall, 2005 and Crosby, 2007; among others). In this paper, due to data availability, regional patent applications by millions of inhabitants are used to measure R&D output performance. Results are presented in column 5. In this case, unlike input variables, evidence in favor of a significant relation between patents and economic growth is present in the data.

The FE-estimator still rests on the assumption of strict exogeneity. If it is violated, we have an endogeneity problem: the independent variable and the idiosyncratic error term are correlated. Under endogeneity the FE-estimator will be biased. To circumvent the endogeneity issue the standard procedure is to use instrumental variables estimation, Two-Step Least Squares (2SLS) or Generalized Method of Moments (GMM). Although it is argued that the GMM approach deals consistently and efficiently with endogeneity problems, this procedure critically hinges on the assumption of no second-order serial correlation in the errors of the equations in levels. For the estimations considered here, the AR(2) tests suggest that, generally speaking, our equations do not satisfy such a necessary condition and, therefore, we apply 2SLS instead. In this case, results from the 2SLS models are very similar to those obtained from the FE-estimation. Although estimate figures are not the same they exhibit the same sign and statistical level of significance.

In the IV-estimation, table 6, real GDP growth rate depends positively on the gross capital formation and the employment-population ratio. As in the previous case, total R&D expenditure exerts a significant influence on economic growth; the same happens with the total number of researchers and the number of patent applications. When disaggregated by type of R&D, again, only the activity performed by the business sector, in terms of expenditure and researchers, presents a significant impact on GDP growth.

Table 6. R&D and Growth, Spanish Regions, 1995-2008 (2SLS).

Estimation method: Two-Stage Least Squares.
Dependent Variable: Real GDP Growth Rate.

	(1)		(2)		(3)		(4)		(5)	
$GDP_{(t-1)}$	-0.187	***	-0.236	***	-0.241	***	-0.223	***	-0.226	***
	(0.039)		(0.036)		(0.028)		(0.030)		(0.041)	
Investment	0.067	**	0.042	**	0.035	*	0.059	***	0.072	**
	(0.027)		(0.021)		(0.021)		(0.022)		(0.034)	
Employment	0.097	**	0.186	***	0.189	***	0.147	***	0.132	**
	(0.046)		(0.045)		(0.036)		(0.040)		(0.065)	
$R\&D_{total}$ Expenditure	0.015	*								
	(0.008)									
$R\&D_{gov}$ Expenditure			0.008							
			(0.006)							
$R\&D_{univ}$ Expenditure			-0.007							
			(0.019)							
$R\&D_{bus}$ Expenditure			0.007	**						
			(0.003)							
$R\&D_{total}$ Researchers					0.018	*				
					(0.011)					
$R\&D_{gov}$ Researchers							-0.012			
							(0.008)			
$R\&D_{univ}$ Researchers							-0.006			
							(0.005)			
$R\&D_{bus}$ Researchers							0.010	*		
							(0.006)			
Patent applications									0.026	**
									(0.011)	
# Observations	170		187		204		204		163	
Adjusted R^2	0.361		0.391		0.509		0.446		0.324	
Hansen J test for over-identification	0.269		0.189		0.198		0.236		0.162	

Source: own elaboration

Notes: ***, ** and * represent significance at the 1%, 5% and 10% level. Robust standard errors in parenthesis. The outcomes from the Hansen J tests are p-values (H_0: Instruments are valid). All explanatory variables are in natural logarithms. Regional and time fixed effects are considered.

It follows from these results that the allocation of resources to R&D activities by firms is crucial, whereas, according to our analysis, the government spending does not seem so essential for regional growth. The reasons for this may be several - measurement errors or lack of efficiency in the allocation and execution of projects financed by the public sector, among others- and will be examined in detail in further research. It could also be the case that we do not find a positive impact of public R&D on growth because the public sector mainly finances basic research, whose effect on growth is slower and less detectable.

These results question the effectiveness of science policies based on promoting regional public investment in R&D as a means of generating economic growth. It seems more effective and efficient to encourage and develop a legal and economic framework where companies could carry out innovation activities. The issue becomes more important within the present debate on the high levels of deficits and debt of central and regional governments. In the current scenario, society is increasingly aware of the need to allocate scarce resources as efficiently as possible since there is an opportunity cost –in terms of spending on education, health or pensions– to which the society is particularly sensitive.

These results also invite to raise a number of important questions on the design of public science policies: What should be favored from the state, the basic or applied science? How R&D expenditure could be more efficient? Who should establish which areas are to be supported? In parallel, it should not be concluded from this study that the impact of resource allocation to R&D by the government is inexistent. Without basic research, largely financed by public funds because of, among other things, the nature of non-rival and non-excludable knowledge generated by this activity, it might be impossible or very difficult to build applications with market value. Perhaps part of the problem is that the nexus between basic and applied research is no yet known in sufficient detail.
These considerations help not to be misled by a number of fallacies and clichés which are often heard. A decrease in public spending on R&D, for example, need not manifest itself in a decline in the growth rate in the next five years. We do not know if those funds were to finance projects of little practical application in the short term or even long term. And the opposite is not true: there is no guarantee that an increase in public R&D funding leads always to growth in output.

5. Concluding Remarks

This paper analyzes some features about R&D activities in the recent past in Spain, at the national and regional level. A first look at the data suggests that the Spanish R&D expenditure intensity, and specifically that performed by the business sector, is lower than in the UE or the OECD countries. This idea coincides with the fact that Spain is well positioned in terms of basic research measured by papers per researcher, but this is not the case in terms of patents. A deeper look at regional data highlights that R&D activities concentrate in few regions: Madrid, País Vasco, Navarra and Cataluña.

The empirical analysis carried out points out that spending on R&D activities, as well as patents, employment and gross capital formation, have contributed to the economic growth of the Spanish regions during the period analyzed. If R&D expenditure is disaggregated by sectors, only business R&D, measured either by the expenditure-to-GDP ratio or the participation of researchers over employment, has a clear positive impact on growth. The R&D spending and number of researchers of the public sector and the universities, instead, do not exhibit a positive and significant correlation with economic growth. It follows from these results that the allocation of resources to R&D activities by firms is crucial, whereas, according to our analysis, the government or university spending do not seem so essential for regional growth.

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