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Innovation, entrepreneurial activity and competitiveness at a sub-national level

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Abstract The capability to generate new knowledge and to create new firms differs across regions. Our study is an attempt to test the extent to which differences in such capabilities are associated with regional competitiveness. Using data from Spanish NUTS2 regions for the period 2000–2004, our results show that a higher capacity of a region to simultaneously generate new knowledge and start-up firms is positively linked to its level of competitiveness. This finding supports the belief that innovation per se is a necessary, but not sufficient, condition for regional economic development.

Keywords Entrepreneurial activity · Innovation · Productivity · Regional competitiveness

JEL Classifications R11 · O33 · D24 · L26

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1 Introduction

During the last decade much attention has been devoted to the study of territorial competitiveness and development. Recent studies suggest that the ability of a territory to create new knowledge and to nurture new businesses is crucial for economic development (Audretsch and Keilbach 2004a, 2004b; Wong et al. 2005). Yet little is known about how the interface of such capabilities affects the economic development of (sub-national) regions. Although comparative studies across countries on entrepreneurship and economic development abound in the literature, scholars claim that more research is needed to gain a better understanding of the key drivers of competitiveness of smaller-scale regions. Indeed, results from an increasing number of studies suggest that sub-national regions are the basic spatial units in which development processes leading to territorial competitiveness arise (Cooke and Schienstock 2000; Isaksen 2005; Porter 2003; Scott and Storper 2003).

A society's competitiveness is mirrored by its ability to gradually maintain and increase the economic welfare of its citizens (Fagerberg 1996; OECD 1990). Economic growth has been traditionally measured as variation in income per capita, which results from workforce and capital productivity improvements to a large extent. According to Porter (1990), "the only meaningful concept of competitiveness at national level is productivity" (p. 76). In our study, we contend that higher regional productivity will lead also to advanced stages of competitiveness and economic welfare.

Why do most European countries still face the so-called "knowledge paradox" (i.e., high investment in new knowledge creation parallel to low economic growth rates)? Why do many low-income countries evince an "entrepreneurial paradox" (i.e., high firm formation rates without showing a major improvement in their level of GDP per capita)? An answer to these puzzling questions, and a plausible explanation of these counterintuitive phenomena, is that not all innovation efforts lead to higher competitiveness, because the economic value of knowledge is perceived differently among people (Arrow 1962) and entrepreneurship per se is not the panacea for economic growth.

The purpose of our study was to examine empirically the linkage between the level of competitiveness of a region and its simultaneous capacity to generate new knowledge and start-up firms. This article adds to the literature on regional competitiveness in three ways. First, we explain why new knowledge generation and entrepreneurial capabilities are related to regional productivity and test this linkage empirically. Audretsch and Keilbach (2004b, 2008) consider regional innovation and entrepreneurial activity as resources (i.e., added input factors of a production function). Our approach is different. We consider the superior ability to create new knowledge and new firms as a regional capability, rather than a local resource, linked to the total factor productivity of a territory. Moreover, we test the relationship between such capabilities and regional productivity from a dynamic perspective. Second, while country-level studies proliferate in the field of entrepreneurship (studies based on data from the Global Entrepreneurship Monitor, GEM, project are a good example), the literature, with very few exceptions, still lacks studies conducted at a sub-national level. We recognize the existence of intra-national heterogeneity of territorial productivity and capability endowment, and, accordingly, we test our model at a NUTS2-region level in Spain. Last, we show that innovation is a necessary, but not sufficient, condition for regional productivity improvement.

The study is divided in five sections. Following the introductory section, a conceptual framework is developed to explain the relationship between regional capabilities and competitiveness. Empirical hypotheses are derived from this model. We then describe the data and methodology in Sect. 3 used for our empirical work. In Sect. 4 we summarise the main findings of the study, and the paper ends with final conclusions and implications.

2 Regional resources and capabilities

2.1 Productivity and regional capabilities

Solow's (1956) neo-classical model of growth considers the share of growth not explained by labour and capital inputs as being a result of technological progress and improved knowledge. In terms of a Cobb–Douglas production function, this model explains the generation of wealth Y_{it} in region (i) at time (t) as a function of the effective use of labour supply (L_{it}), the physical stock of capital (K_{it}) and the term A which, in Solow's own words, is to be interpreted as technological change. More generally, A is referred to as the total factor productivity (TFP).[1]

$$Y_{it} = Af(K_{it}, L_{it}) \quad (1)$$

This model captures technological change as an exogenous element that affects productivity or the ability to combine efficiently the inputs available to obtain output(s). Thus, economic growth depends on both the availability of productive inputs (i.e. labour and capital) and the use made thereof (Romer 2007). We not only distinguish between inputs and the efficient use of them, but also consider these notions as *resources* and *capabilities*, respectively.

Neoclassical economic theory explains how perfectly competitive markets work under the assumption of homogeneous goods. More specifically, firms transform homogeneous inputs into homogeneous outputs, yielding profits which supposedly tend to converge to zero in the long run. This process ensures market equilibrium under perfect competition. In contrast, the theory of the firm holds that organizations

[1] The Romer (1986) model is an extension of the neo-classical model in which knowledge, R_{it}, is added as an input and, more specifically, is considered an endogenous element of technological change, in addition to human capital (Romer 1990).

develop firm-unique capabilities. Such capabilities are heterogeneous across organizations. Moreover, firms seek supra-normal profits in the long run leading to market disequilibrium (Penrose 1995). These organizational capabilities are firm-idiosyncratic by nature and this variation may explain the existing variation in business performance (Barney 1991; Lippman and Rumelt 1982). The same rationale can be applied, by extension, to *regional capabilities* (Best 1999). In this sense, the notion of firm capabilities is equivalent to the use made of territorial resources (i.e., at an aggregated level).

Following this line of thinking, we will argue that the idiosyncratic abilities to generate new knowledge and to create new ventures are heterogeneous *capabilities* that differ across regions; these unique capabilities determine the use of labour and capital, which supposedly happen to be homogeneous *resources* physically available within a region. Whereas labour and capital are tangible resources that may be imitable to a large extent and tradable within markets (i.e., at market prices such as labour wage and capital return), the ability of a region to create new knowledge and new ventures is an intangible capability which is non-tradable and, presumably, difficult to replicate (i.e., many economic development authorities will be eager to "buy" the innovation and entrepreneurial capability of, for instance, Silicon Valley, for their regions if there was a market for such capabilities). Therefore, intangible capabilities are developed through an experiential and knowledge-creating process that depends on how regional resources are used and developed.

Because capabilities represent the efficient use of resources (Dutta, et al. 2005), we shall consider regional (innovation, *I,* and entrepreneurial, *E*) capabilities as intangible elements that are linked to increased productivity. Hence, we include them into the term *A* in Eq. 1, where $A = f(I,E)$. In line with the rationale behind the theory of the firm, the capability to create new knowledge and firms is heterogeneous across regions, and this heterogeneity may partially explain variation of the prosperity of regions. Recent studies discuss the dynamic nature of capabilities at organizational (Eisenhardt and Martin 2000; Zahra et al. 2006) and regional (Best 1999) levels. We assume that the innovation and entrepreneurial capabilities of regions generate dynamic outcomes that change over time. Consequently, we also add a time dimension into our model.[2]

On the basis of the aforementioned arguments, and consistent with the literature (Bloom et al. 2007; Dutta et al. 2005; Murphy et al. 1991; Rosen 1982; Vendrell-Herrero 2008), we subsume labour (L_{it}) and physical capital stock (K_{it}) under the heading of "*resources*", whereas we place under the heading of "*capabilities*" the ability to generate new knowledge (I_i) and to create new ventures (E_i). Both elements determine the time-variant productivity (A_{jt}) for different sub-national regions (*j*). For practical purposes we follow a standard Cobb–Douglas production function and assume constant returns to scale (for more details see Wong et al. 2005, pp. 348–349). Equation 2 represents our formal model.

$$\frac{Y_{jit}}{L_{it}} = A_{jt}(I_i, E_i)\left(\frac{K_{it}}{L_{it}}\right)^{\alpha} \tag{2}$$

It is worth stressing that our model adds three important properties:

1. it explicitly highlights the view of new knowledge and firm creation ability as capabilities;
2. it introduces a dynamic perspective; and
3. it focuses on a regional (sub-national) level of analysis.

2.2 Regional innovation capability

Regional innovation capability, understood as a region's ability to create new knowledge, has emerged as an important source of competitive advantage (Porter 1990). In this sense, regions with a rich knowledge base provide firms located in those geographical areas with opportunities for innovation that generate increasing returns at a firm level, and ultimately economic growth at an aggregated level. While globalisation today makes it possible for physical capital to be transferred to countries where labour is cheaper, the knowledge base encouraging

[2] Zahra et al. (2006) analyse in detail the concept of "dynamic capability", distinguishing between the knowledge base at a given time (substantive capacities), the potential to increase this knowledge base over time (dynamic capabilities), and the result (economic growth). We shall define dynamic capabilities and regional economic growth as the following notations, respectively: $Ln\left(\frac{A_{t+1}}{A_t}\right); Ln\left(\frac{Y_{t+1}}{Y_t}\right)$.

innovation is harder to move (Arrow 1962). Hence, the competitive advantage of developed countries tends to be based on knowledge-and-technology-intensive production. Not surprisingly, public policies of advanced economies focus on the strengthening of knowledge and innovation platforms through investment in human capital and research and development (R&D), the protection of intellectual capital, etc.

Economic growth does not result automatically from increases in labour or capital endowment but, rather, the introduction of new methods, products and services based on scientific knowledge and recent technological innovations yield monopolistic rents and provoke market instability (Schumpeter 1934). It is widely accepted that technological change and innovation are fundamental sources of productivity and sustainable growth (O'Mahony and van Ark 2003). Furthermore, technological change and innovation are the result of previous R&D efforts (Acs and Varga 2005). More dynamic and competitive regions are typically better endowed with highly skilled human capital enabled to absorb and generate new knowledge in places with a high R&D intensity level (Cantwell and Janne 1999).

As both the economic and social value of new knowledge creation increase, the incentive to innovate should be higher, and vice versa. Despite the endogenous process of this path,[3] we examine the existence of correlation, instead of causality, between the new knowledge-creation capacity and the productivity level of a region. In particular, we expect that more innovation-driven regions are associated with higher productivity levels.

H1 Regions with high innovation capability have a higher level of productivity than regions with a lower innovation capability.

2.3 Regional entrepreneurial capability

The subject of entrepreneurial activity and economic growth has attracted the attention of an increasing number of scholars and policy makers during the last decade (Sternberg and Wennekers 2005). Moreover, the effect of entrepreneurial activity on economic growth has been analysed from multiple perspectives (Audretsch and Keilbach 2004b, 2008; van Stel et al. 2005; Wong et al. 2005). In a recent study, van Stel et al. (2005) found a positive relationship between entrepreneurial capacity and economic growth in advanced economies, but a negative relationship in less developed countries.[4] Erken et al. (2009), p. 9, claim that "with increasing economic development the importance of entrepreneurship decreases quantitatively but increases qualitatively". Other authors believe that while a "managed economic regime" favouring the economic role of incumbents dominates in less developed countries, an "entrepreneurial economic regime" prevails in more developed countries (Audretsch and Thurik 2001; Wennekers et al. 2010; Wennekers et al. 2005). In addition, Fritsch and Mueller (2008) suggest that the effects of entrepreneurial activity are spread in different phases over time up to approximately 10 years, with some periods experiencing a positive impact, and others without any impact or even with a slightly negative effect. In general, all these studies agree that the effects of entrepreneurial activity vary depending upon both the stage of economic development of each country and the time horizon.

Conventional wisdom suggests that the entrepreneurial capability of an economically advanced region affects positively productivity, because new market entrants are supposed to contribute positively to efficiency gains by increasing competition (Porter 1998; Segarra and Callejón 1999), creating highly skilled jobs (van Stel and Storey 2004), and/or adding more sophisticated novel goods to the marketplace (Casson and Wadeson 2007). Accordingly, we propose the following hypothesis:

H2 Regions with high entrepreneurial capability have a higher level of productivity than regions with a lower entrepreneurial capability.

[3] We leave for further research the study of the endogenous process of this virtual cycle between economic development and innovation.

[4] Apart from academic studies, some of the principal contributions to the analysis of entrepreneurial activity and economic development in countries and regions have come from reports published by the GEM project over the past few years. Such results also show that entrepreneurial activity in less developed countries correlates negatively with per capita income and that, on achieving a certain welfare level, a threshold is reached after which the relation becomes positive for the more developed countries.

2.4 The simultaneous effect of both innovative and entrepreneurial capabilities on regional productivity

We think that regions with a better capacity to create new knowledge and a better ability to channel innovative products/services/technologies through new ventures will go through a more rapid and pronounced economic development process. Both conditions *together* are important for improved regional productivity.

Some regions with a high stock of knowledge experience low economic growth, whereas other regions with a lower capacity to generate knowledge show the opposite (Acs et al. 2009). For instance, countries like Japan and Sweden have high levels of expenditure on R&D but modest GDP per capita growth rates (Audretsch 2009; Audretsch and Keilbach 2008). This suggests that innovation does not lead necessarily to resilient economic growth.

Certainly, distinct types of entrepreneurial activity have different effects on economic growth (Hessels et al. 2008).[5] In a process of *creative construction* (Agarwal et al. 2007), *innovative* entrepreneurs take advantage of existing knowledge, already generated (although underutilised) by incumbents, to create opportunities for innovation that do not necessarily displace rival firms. Moreover, when starting a new venture, entrepreneurs eventually generate new knowledge, thus creating further opportunities for innovation that will be recognised and exploited by others. Thus, the extent to which a region invests in new knowledge generation helps increase the stock of existing knowledge. We believe that the wealth of a region will increase as long as its capacity to drive innovation to the marketplace through entrepreneurial activity is effective (Audretsch 2009). Thereby, the interface of new knowledge creation and entrepreneurial activity has an important economic implication. Audretsch and Keilbach (2008) expand this argument further and believe that entrepreneurs play a fundamental role in all development processes as they become the conduit for spreading and commercializing new knowledge that would otherwise remain non-commercialised. The authors point out that it is the simultaneous effect of both innovative and entrepreneurial capacity in an entrepreneurial society that actually determines regional competitiveness and economic development.

In short, we expect that regions with better capacity both to generate new knowledge (i.e. where knowledge spillovers prevail) and to create new ventures (i.e. where a relevant part of adult population is involved in start-up processes) will also have greater productivity than less innovative and entrepreneurial regions. Notice that, again, we avoid testing for any causality relationship because of the endogenous process of the regional growth path. We just compare the productivity level of regions with different innovation and entrepreneurial capabilities, by taking into account these capabilities together rather than separately.

H3 More innovative and entrepreneurial regions will achieve greater productivity than those with a lower innovative and/or entrepreneurial capability.

3 Data and methodology

3.1 Model specification

Our model enables estimation of territorial productivity, under a dynamic perspective, by considering the effect of the capabilities to generate new knowledge and start-ups. We make the empirical assumption that productivity varies across groups of regions with similar endowment of innovation and entrepreneurial capability, but not across individual members in each group of regions. We also assume that, although productivity is not constant over time, the composition of each group of regions does not change in the short-run. Accordingly, we specify the productivity term A_{jt} of our model by differentiating groups or categories of sub-national regions (S_j), by adding a dynamic component (t), and by considering the interaction effect of both the territorial and time dimensions (S_j*t). Equation 3 is the empirical specification of the productivity term (A_{jt}).

$$A_{jt} = e^{\alpha_0+\alpha_1 t+\sum_{j=1}^{3}\left(\lambda_j S_j+\mu_j t*S_j\right)} \quad (3)$$

The productivity term (A_{jt}) in our production function (i.e., Eq. 2) is replaced with Eq. 3. After

[5] For instance, empirical evidence suggests that entrepreneurs with high-growth aspirations and those committed to global markets are more likely to contribute to economic growth than other entrepreneurs (Hessels and van Stel 2009; Wong et al. 2005).

applying a logarithmic transformation, we obtain the following general expression which we shall test through robust OLS estimation (Vendrell-Herrero 2008):

$$Ln\frac{Y_{jit}}{L_{it}} = \eta_0 + \eta_1 t + \sum\nolimits_{j=1}^{3} \left(\lambda_j S_j + \mu_j t * S_j\right) + \alpha Ln\frac{K_{it}}{L_{it}} + \varepsilon_{jit} \quad (4)$$

3.2 Definition of variables

We collected panel data for all the NUTS2-level Spanish regions (17 regions), within a five-year time period. Overall, our sample includes 85 observations. A brief description of the variables follows.

Our dependent variable, *Real GDP* (Y_{it}), is measured by the gross domestic product, adjusted for price changes and inflation, in millions of Euros (constant prices of 2000) for each Spanish region over the period 2000–2004. The data for this variable come from the Spanish Regional Accounts database provided by the Spanish National Statistics Institute (Instituto Nacional de Estadística, INE[6]). As mentioned above t denotes the dynamic component and it ranges from $t = 1$ (year 2000) to $t = 5$ (year 2004). We use two independent variables to represent resources or input factors (i.e. capital and labour) for each sub-national region. First, *Physical capital stock* (K_{it}) represents the capital input factor of our production function. This variable is measured by the net capital stock adjusted for price changes and inflation (constant prices of 2000, in millions of Euros), not including the value of housing.[7] The data for each Spanish region over the period 2000–2004 are provided by the BBVA Foundation and the Valencian Economic Research Institute (Fundación BBVA-IVIE 2007). Second, *Employed population* (L_{it}) denotes the labour input factor of our production function. This variable corresponds to the labour force or economically active population for each Spanish region during the period 2000–2004. The data are measured in thousands of employees and its source is the Economically Active Population Survey provided by the INE.

Innovation and entrepreneurial capabilities are difficult concepts to measure. We have created the variable S_j, which defines the corresponding typology of each sub-national region based on its innovation and entrepreneurial capabilities. We use latent variables to describe these unobservable concepts. On the one hand, innovation capability, as measured by the capacity to create new knowledge, may be inferred from the effort made in R&D activities within a region. We created two variables, one representing R&D expenses per employee, in Euros, and another describing the number of researchers working in R&D activities (full-time equivalent) per thousand employees for each Spanish sub-national region. The data for both variables come from the database Statistics about R&D Activities provided by the INE. The entrepreneurial capability of sub-national regions is represented by the intensity of new firm formation and the involvement of the population in the process of starting-up new businesses. We gathered data from the Central Companies Directory of INE to estimate the rate of net firm entry for each Spanish region. Likewise, we added another entrepreneurship-related variable, the total entrepreneurial activity index (TEA) at a sub-national level, provided by the Global Entrepreneurship Monitor (GEM) project. This latter indicator describes the percentage of the adult population that owns and manages a new business that has paid salaries for less than 42 months (3.5 years). Hence, the data for years 2004–2006 actually correspond to people who started-up a new business some time between 2001 and 2006. We use average values of all these descriptors to harmonize the timeframe and to minimize the effect of outlier observations.

Next, we performed factor analysis to group the four capability-related variables into separate dimensions. More specifically, we applied principal-components analysis (PCA) to determine whether all these indicators share some commonalities across two dimensions, namely regional innovation capability and regional entrepreneurial capability. The Kaiser (1960) criterion suggests retaining all factors with eigenvalues greater than 1.0. Accordingly, we extracted the two first factors which account for

[6] See http://www.ine.es for more information.

[7] Net capital stock is a common measure of capital contribution to growth even though productive capital is the most appropriate measure. However, the latter is not published at an aggregated level for each region. Accordingly, in order to use a more proper measure of capital, the value of housing was subtracted from the net capital stock value because it is not directly involved in production and may reflect speculative activities.

Table 1 Factor and cluster analysis

Factor analysis	Factors	
	1	2
Innovation capability variables		
R&D labour	*0.99*	−0.05
R&D expenses	*0.98*	−0.09
Entrepreneurial capability variables		
Total net entry	0.09	*0.82*
TEA	−0.20	*0.65*

Cluster analysis

Cluster	No. of regions	Factor 1		Factor 2	
		Mean	Std. Dev.	Mean	Std. Dev.
A (=S_2)	8	−0.42	0.43	0.76	0.48
B (=S_1)	5	−0.58	0.55	−1.05	0.43
C (=S_4)	3	1.62	0.55	0.23	0.69
D (=S_3)	1	1.39	–	−1.53	–

Notes Rotated component matrix using Varimax rotation. Because of data constraints these analysis are conducted for the period 2004–2006. Factor loadings themselves are used as a criterion for testing the significance of a given item (or variable) in a given factor. Thus, factor loadings above 0.3 are taken as large enough to indicate the loading is salient are indicated in italics (Tabachnick and Fidell 2001)

77.58% of the total variance.[8] These factors were rotated using the Varimax rotation method in order to obtain a simplified structure of loadings matrix, with uncorrelated factors more easily interpretable (Costello and Osborne 2005). Results are shown in Table 1. The first factor is highly and positively associated with the two innovation-related variables (i.e., factor loadings over 0.70), but not with the entrepreneurial-related variables. In contrast, the second factor is highly and positively associated with the entrepreneurial-related variables but not with the innovation-related variables. Thus, the first factor represents the dimension of regional innovation capability whereas the second factor represents the dimension of regional entrepreneurial capability.

On the basis of the factor loadings obtained for each case, we used hierarchical cluster analysis to classify the Spanish regions along these two dimensions (i.e., innovation and entrepreneurial capabilities). From the dendogram shown in Fig. 1, we identified four clusters of regions. The bottom side of Table 1 provides the mean and standard deviation of the factor-loading values for each of the four cluster groups. Cluster A has a relatively low and negative loading on factor 1 and a positive loading on factor 2, which suggests that this group may be characterised as regions with low innovation capability and high entrepreneurial capability. Cluster B shows negative loadings on both factor 1 and factor 2, which mean that these regions have low levels of innovation and entrepreneurial capabilities. In contrast, cluster C has a highly positive loading on factor 1 and a positive, though relatively low, loading on factor 2; therefore, these regions seem to have high levels of innovation and entrepreneurial capabilities. Finally, cluster D has a highly positive loading on factor 1 and a highly negative loading on factor 2, which indicates that this group is characterised by a high innovation capability and a low entrepreneurial capability. Overall, some regions are at an advantage in innovation capability and/or entrepreneurial capability whereas others fall behind the rest in both kinds of capability.

The four clusters or categories of regions identified in the cluster analysis are mapped in Fig. 2, with each group represented by our capability-related variable, S_j (where $j = 1,\ldots, 4$). The regions characterised by low innovation capability and low entrepreneurial capability (cluster B) are denoted by S_1; the regions characterised by low innovation capability and high entrepreneurial capability (cluster A) are denoted by S_2; the regions characterised by high innovation capability and low entrepreneurial capability (cluster D) are denoted by S_3; and, finally, the regions characterised by high innovation capability and high entrepreneurial capability (cluster C) are denoted by S_4.

From this classification, we have created a set of dummy (dichotomous) variables to define innovation and entrepreneurial capabilities through four *capability typologies* (S_j).[9] Thus, each dummy variable

[8] Similarly, the *scree test* (Cattel 1996), based on examining the graph of eigenvalues and looking for the natural break point from which the curve flattens out, suggests retaining two factors.

[9] These dummy variables are embedded in the productivity term A_{jt}, except for that representing the reference category.

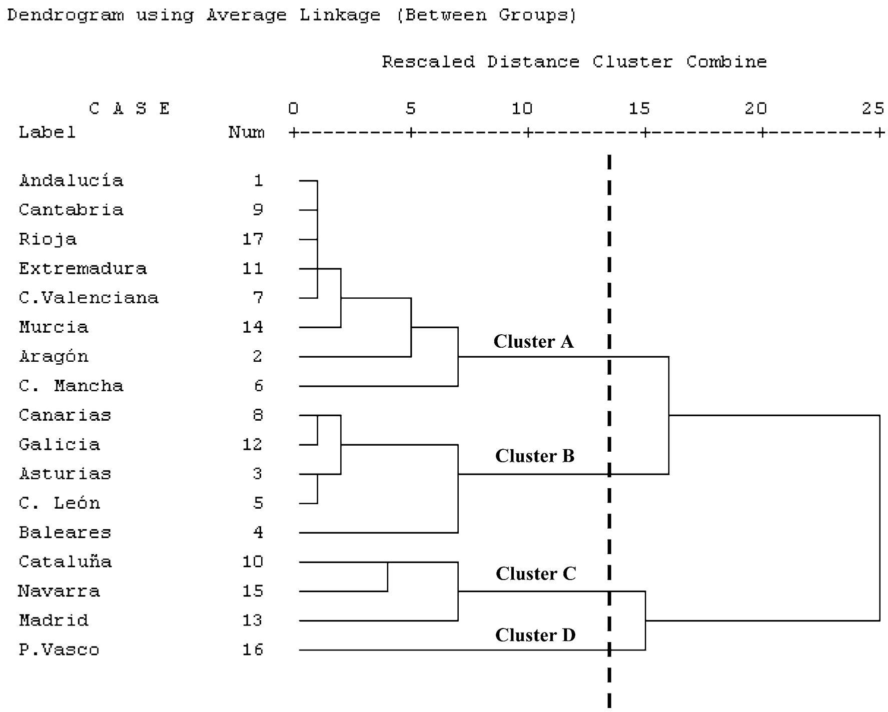


Fig. 1 Dendogram from cluster analysis based on factors of innovation and entrepreneurial capability

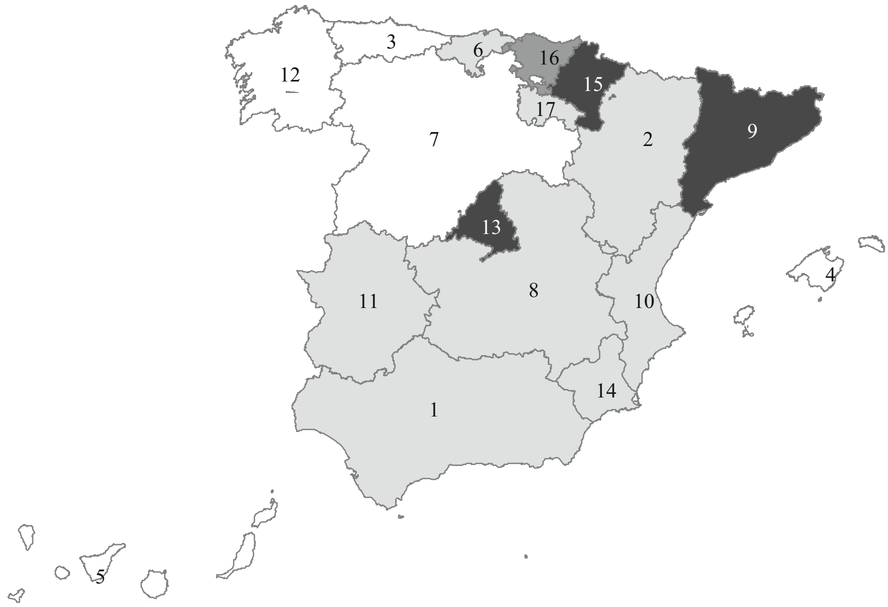
takes the value unity in all periods analysed for the regions belonging to the typology of capability that corresponds to that variable ($j = 1, 2, 3, 4$), and zero otherwise. Note that, for empirical purposes, we assume cross-region homogeneity within each typology of regions with the same level of innovation and entrepreneurial capabilities.

3.3 Descriptive statistics

Figure 2 also shows the spatial distribution of regions according to the variable of capability typologies. Catalonia, Madrid and Navarre are regions with high levels of both innovation capability and entrepreneurial capability (S_4) whereas Asturias, the Balearic Islands, Castile and León, the Canary Islands and Galicia have low activity levels of both innovation and entrepreneurial capabilities (S_1). The Basque Country is the only region with high innovation capability that is characterised by an entrepreneurial capability below the average (S_3). Finally, the remaining regions have low innovation capability and high entrepreneurial capability (S_2). For more details about the characterisation of each cluster, descriptive statistics for the four variables used in the principal-components analysis and cluster analysis are shown in Table 2.

Our results show that Madrid, Catalonia, Basque Country and Navarre have the most developed technological infrastructures for innovation within Spain. This finding supports previous results by Buesa et al. (2002). The communities of Madrid, Catalonia and Navarre (S_4 type of sub-national region) not only have vigorous entrepreneurial activity (i.e., above average annual new firm entry rates in Spain), but also, they invest solidly in innovation activities. These communities, with the Basque region, rank high in the indicator of *business technology stock of capital per capita*—which is approximately equivalent to the accumulated investment in R&D. Buesa et al. (2002) found that, on average, the abovementioned four regions have a value of 585€ on this indicator, which is about seven times larger than that of the remaining regions in Spain (78€). The Basque Country (S_3 type of sub-national region) is the pioneer region in building and developing technology parks in Spain and the region with the largest number of technology centres (18 centres according to Buesa et al. 2002). Nonetheless, the Basque region does not rank as high as Madrid, Navarre or Catalonia in firm formation rates. Certainly, the Basque region is not so suitably endowed with academic institutions that spur university spin offs. Indeed, the Basque region lacks prestigious Business

Fig. 2 Regional grouping by innovation and entrepreneurial capabilities



Nº	Region	Nº	Region
1	Andalusia	10	Valencia
2	Aragon	11	Extremadura
3	Asturias	12	Galicia
4	Balearic Islands	13	Madrid
5	Canary Islands	14	Murcia
6	Cantabria	15	Navarre
7	Castile and León	16	Basque Country
8	Castile-La-Mancha	17	La Rioja
9	Catalonia		

S_1 Regions: Low innovation capability and low entrepreneurial capability
S_2 Regions: Low innovative capability and high entrepreneurial capability
S_3 Regions: High innovative capability and low entrepreneurial capability
S_4 Regions: High innovative capability and high entrepreneurial capability

and Engineering schools[10] where the entrepreneurial spirit is more widely spread and developed through alumni venture capital clubs, business incubators, etc. In addition, firm formation is typically larger in the service industry sector, but the weight of the manufacturing industry sector in the Basque economy is higher than elsewhere in Spain. These are plausible explanations to distinguish S_3 regions from S_4 regions.

The communities of Andalusia and Extremadura are the regions under the heading S_2, where the innovation capacity is low but the entrepreneurial capability is high. Although these region have typically had large levels of unemployment (Abascal-Fernández et al. 2006), they also have a constant and positive balance of inter-region migration.[11] In other words, these regions seem to offer attractive opportunities for self-employment. In contrast, regions in the S_1 category, with both low innovative and entrepreneurial capabilities, are basically peripheral territories of Spain (e.g. the Canary and Balearic Islands) and/or have a negative inter-region migration balance (e.g. Galicia). Besides having above normal unemployment and a weak endowment of technological infrastructure for innovation, these regions do not provide an adequate business environment nor sufficient incentives for self-employment.

[10] For example Catalonia has top international Business Schools such as ESADE (http://www.esade.edu) and IESE (http://www.iese.edu) and a Engineering School with a wide academic offer (UPC, http://www.upc.edu).

[11] Inter-region migration is measured as the residential variation using data from INE.

Table 2 Descriptive statistics for capabilities and production function's variables

Type of regions	Number of regions	Innovation capability				Entrepreneurial capability				Output and resources				
		RD labour		RD expenses		Total net entry		TEA		Real GDP (millions of Euros 2000)	Real net capital stock (millions of Euros 2000)	Employment (thousands of employees)		
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	(Yit) Mean 00–04	(K_{it}) Mean 00–04	(L_{it}) Mean 00–04	(Y_{it}/L_{it}) Mean 00–04	(K_{it}/L_{it}) Mean 00–04
S_1	5	6.07	2.28	256.20	102.00	3.54	1.10	5.36	0.70	26,037	59,700	700	37,980	87,085
S_2	8	6.19	2.13	255.18	69.04	4.22	1.39	7.12	0.98	30,046	68,239	830	37,115	89,304
S_3	1	13.68	–	732.11	–	1.42	–	5.38	–	41,943	91,682	889	47,126	102,959
S_4	3	14.67	2.62	755.86	149.59	3.51	1.84	6.57	0.61	85,711	153,246	1,877	46,044	87,501
Overall sample	17	8.09	4.16	371.89	232.87	3.73	1.43	6.41	1.12	39,390	82,108	980	39,516	89,137

Table 2 also contains descriptive statistics of the quantitative variables included into the production function (i.e. outputs and resources) for the groups of regions created on the basis of their innovation and entrepreneurial capabilities. According to the last two columns, we observe preliminary evidence for our hypothesis 3. For instance, regions with both high innovation and entrepreneurial capability (S_4) seem to be more productive than those with high innovation capability and low entrepreneurial capability (S_3). Likewise, for an equivalent amount of resources, regions belonging to the S_4 typology would produce much more output than regions belonging to the S_1 and S_2 typologies (i.e., 21.2 and 24% more output, respectively).

4 Results

Three models aimed at calculating the effects of innovation capability and/or entrepreneurial capability on regional productivity (i.e., economic growth) were tested (Table 3). In order to control for non-observed heterogeneity, all the models included regional fixed-effects.[12]

[12] Although innovation and entrepreneurial capabilities are considered under the heading S_j, there are other relevant regional not observed characteristics (i.e. sector distribution, degree of competition, foreign investment, etc.) that are associated with economic growth or productivity. The case of Madrid is a clear example, it concentrates all the relevant public institutions (national such as ministries and international such as embassies), it is increasingly specialized in financial services (most of the Spanish commercial banks have moved their central offices to Madrid) and jointly with Catalonia has the most well-renowned Spanish universities. In econometric terms, both random and fixed effects deal with those not observed characteristics. The Hausman (1978) test is the accepted tool to determine whether the estimator of fixed effects may be higher than the estimator of random effects. In particular, the null hypothesis of the Hausman test is that the difference between the parameters is not systematic, in other words that the information contained in the random and fixed estimates is no different statistically. In the three models presented in the "Results" section regional fixed effects outperform random effects. For example, in Model 3 the statistical test for our model is 83.79 ($P = 0.0000$) with five degrees of freedom. Besides, the increase of R^2 in the models is close to 40% when fixed effects are included. The results displayed in Table 3 therefore contain the dummy variables of each region (here, Autonomous Community).

Table 3 Effect of resources and capabilities on economic growth

	Explanatory variables	Model 1	Model 2	Model 3
Initial productivity levels	$S_{(1,2)}$	–0.2049***		
	$S_{(1,3)}$		−0.0193	
	S_1			−0.2145***
	S_2			−0.2421***
	S_3			−0.1061***
Productivity growth	t	−0.0108**	−0.0103***	−0.0135*
	$t*S_{(1,\ 2)}$	0.0028		
	$t*S_{(1,3)}$		0.0050	
	$t*S_1$			0.0078
	$t*S_2$			0.0037
	$t*S_3$			0.0083
Resources	$LN(K/L)$	0.5841***	0.5664***	0.619***
Observations		85	85	85
CCAA		17	17	17
Fixed effects		Yes	Yes	Yes
R^2: within		0.3173	0.3474	0.3572
R^2: between		0.1602	0.1835	0.1593

Notes Robust and clustered standard error terms. Dependent variable = LN (Y/L)

*** 1%, ** 5%, * 10%

Model 1 shows whether the regions with high innovation capability (S_3 and S_4) are more productive than the regions with less innovation capability (S_1 and S_2). This model is a particular case of Eq. (4) where $LnA_{jt} = \eta_0 + \eta_1 t + \lambda_{12} S_{12} + \mu_{12} t * S_{12}$. Note that the regions with high innovation capability (S_3 and S_4) are the reference category against which the results must be interpreted. The estimated coefficient $\lambda_{12,}$ −0.2049, is statistically significant at the 0.01 level. That is, on average, regions with a low innovation capability achieve a lower level of productivity than regions with a higher innovation capability. This result confirms Hypothesis 1 and supports the arguments of other authors (O'Mahony and van Ark 2003; Schumpeter 1934).

Model 2 is a particular case of Eq. (4) where $LnA_{jt} = \eta_0 + \eta_1 t + \lambda_{13} S_{13} + \mu_{13} t * S_{13}$. The reference category here is the group of regions with high entrepreneurial capability (S_2 and S_4). The estimated coefficient λ_{13}, −0.0193, has the predicted sign but it is not statistically significant. Therefore, we cannot accept or reject Hypothesis 2.

Our next analysis dealt with the test of the interactive effect of both regional innovation and entrepreneurial capabilities (Eq. 4). The reference group in Model 3 is S_4. All the estimated coefficients are negative ($\lambda_1 = -0.2145$, $\lambda_2 = -0.2421$, and $\lambda_3 = -0.1061$) and statistically significant at the 0.01 level. This suggests that regions with low innovation capability and/or low entrepreneurial capability are less productive than the reference group of regions with both high innovation and entrepreneurial capabilities, for which productivity is highest. Hence, Hypothesis 3 is confirmed. This empirical finding is an interesting contribution to the extant literature, because it proves Audretsch's argument that both innovation and entrepreneurial capacities *together* are important drivers of regional development (Audretsch 2009).

Although we observe that after the fifth year (i.e., 2004) of our sample the differences remain significant in all cases, at least at a 0.05 level, there are two findings concerning the dynamic evolution of productivity differences that deserve some comment. First, productivity growth declines over time: the coefficient of t is consistently negative, $\eta_1 < 0$, in all models. Second, the coefficient of t for each typology of regions shows a positive value, $\mu_j > 0$. This result means that productive differences among groups of regions tend to converge over time, because the most innovating and entrepreneurial regions improve productivity at a smaller rate than the rest of Spanish regions. This result is consistent with previous literature on regional convergence in international contexts (Barro and Sala-i-Martin 1991) and also in Spain (De la Fuente 2002). This stream of research considers that regional convergence may be expected because of technological diffusion across regions (the so-called catch-up effect), and the reallocation of resources across sectors. Regarding the interpretation of the coefficient for $Ln(K/L)$, the α values of the three models indicate that the elasticity of physical capital stock is slightly higher than that of labour $(1 - \alpha)$. This coefficient is in the usual range reported by other authors (see, for instance, Bloom et al. 2007; Wong et al. 2005).

5 Conclusion

This article tests the effect of new knowledge creation and entrepreneurial capability on regional productivity. Following Wong et al. (2005), we consider the simultaneous ability of a region to generate new knowledge and create new firms as a distinctive capability, rather than a resource, affecting regional competitiveness. In brief, our findings suggest that both innovation and entrepreneurship *together* matter for economic growth.

It is well known that each new generation in our society confronts limits on resources that slow down economic growth. However, new knowledge creation (for which there are no limits) and entrepreneurial activity (as a creative vehicle of capitalisation of innovation) expand the limits of resources to generate economic development, by creating new ideas and commercializing them. Unlike capital and labour, new knowledge creation and entrepreneurial capabilities may be regarded as intangible sources of productivity growth supported by a region's know-how and firm fertility. In fact, the regional heterogeneity in the use of resources only could be explained by either region-specific elements (for example industry specialization controlled in the model through region-fixed effects) or hidden capabilities which are intangible in essence. This reasoning brings into play the concept of "regional capabilities" (Best 1999), whose definition should include a region's capacity for innovation and firm formation as part of the social capital embedded within a territory.

In this regard, an interesting contribution of our study is the empirical test of the effect of innovation and entrepreneurial capabilities on the productivity of Spanish NUTS2 regions, by using a dynamic, rather than a static, perspective. Analyses of this phenomenon from a sub-national viewpoint are scarce in the literature. Previous studies have generally analysed this phenomenon from a static perspective. We believe that our empirical approach, by using sub-national and longitudinal lens, adds valuable insights into the literature. In agreement with the concept of "entrepreneurial society" posited by Audretsch (2009), we found that the most innovating and entrepreneurial regions hold the highest levels of productivity. If small and young companies bring important innovation breakthroughs to the market (Acs et al. 1994, 2009; Audretsch 1995), regional efforts to innovate and to create new ventures seem to be of fundamental importance for economic growth in an entrepreneurial society.

One limitation of this study is the use of categorical variables for the description of regions based on their ability to innovate and create new firms. This is because of the difficulty of obtaining accurate *quantitative* variables to describe innovation (Johannessen et al. 2001) and entrepreneurial activity (Wong et al. 2005, p. 335). We created a typology of regions along these two dimensions in order to offer a pragmatic interpretation of a complex phenomenon. Future research should include more and better quantitative data and/or cover NUTS2 level regions from other economic contexts. Moreover, it would be interesting to point out new elements that could be subsumed into the productivity term (A_{jt}) apart from those analysed in our study (namely innovation capability and entrepreneurial capability). This would allow us to compare the extent to which a region's innovation and entrepreneurial capability is important in comparison with other elements in order to generate and ensure a region′s competitiveness.

Finally, we wish to draw attention to a few implications for public authorities responsible for the design of regional development policies. For regions with low innovation capability and low entrepreneurial capability, steps should be taken to increase the innovative potential of small regions and to nurture an adequate ecosystem in which innovative goods and services can be channelled through successful start-ups. Clearly, policies strengthening both the local entrepreneurial ecosystem and the innovation capacity may be of key importance. For those regions that have achieved or are approaching the status of an *entrepreneurial society* (Audretsch 2009), it is constantly necessary to re-create and re-invent a new competitive landscape. This is particularly important when the development of new technologies with noticeable social returns is currently in place (e.g. the development of the so-called "green" and "clean" technologies). Policy makers should take in mind that forward-looking regional ecosystems at the edge of a knowledge (and production) frontier are better positioned to explore and exploit globally new technological and business opportunities yielding positive firm returns and social welfare.

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