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Abstract

Entrepreneurship capital has been considered in the literature to be a public good, so it will positively affect a region's total factor productivity. There is evidence confirming a positive relationship between entrepreneurship capital measures and regional production. This paper argues that the number of firms in a region will be positively related with the regional production in the presence of decreasing returns to scale in firms' production technology. So if we do not control for the number of firms (and entrepreneurship capital is positively related with the stock of firms) we may be mixing both effects, returns to scale and public goods. This paper provides a methodological benchmark for distinguishing between both effects. The analysis conducted using a sample of 52 Spanish provinces for eleven years suggests major differences and conclusions between methodologies. In our data, previous methods overestimate the effect of regional entrepreneurship capital on the economy.

Keywords: Entrepreneurship Capital, Regional Productivity, Scale Economies.
JEL: R11, L26, O4

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1 Introduction

Although there is general agreement regarding the idea that entrepreneurship contributes to economic growth, how such a contribution occurs, and how important it is, continue to be open questions in entrepreneurship research. One of the methodological approaches to entrepreneurship and growth is that proposed by Audretsch and Keilbach (2004a). This consists of considering entrepreneurship to be a productive input that, together with labour and capital, contributes to the output of the economy, but with one important difference: entrepreneurship is a public good from which everyone in the economy can benefit without hampering the effectiveness of the use of the input by others. This approach has been applied in different institutional contexts such as Germany (Audretsch and Keilbach, 2004a,b,c & 2005; Audretsch et al., 2008; Audretsch et al., 2006; Mueller, 2006 & 2007), European regions (Bönte et al., 2008), Brazil (Cravo et al., 2010), the USA (Stough et al., 2008; Chang, 2011; Hafer, 2013) and the world (Laborda et al., 2011), among others. These studies provide evidence that regional entrepreneurship capital is positively related with regional production. The most commonly used indicators of entrepreneurship capital have been based on the number of firms (incumbent or new, in absolute or relative terms, or their respective growth rates over time).

The paper's contributions to the cited literature are related with the recognition that a region's production is the aggregate of all the production activities of the firms in the region. In a simple model, we show that when the firms' technology has decreasing returns to scale, the number of firms in the region will be positively related with the region's production level. So, if there is a positive correlation between the entrepreneurship capital measure and the stock of firms in the region, the positive relationship between entrepreneurship capital and regional production could also be explained by the presence of decreasing returns to scale.

In other words, given two regions that use the same level of private inputs, a region where firms are smaller on average could be more productive for two reasons: first, the technologies present decreasing returns to scale; second, the total factor productivity of the firms in the region is higher. If entrepreneurship capital is a public good, then it has to be reflected in the total factor productivity of the firms in the region.

So in order to determine which theoretical explanation is relevant, it is important to empirically distinguish between both effects. This has not been done before in the cited literature. In this sense, the main contribution of the paper is to provide a methodological benchmark to help distinguish between these two effects. The proposal is therefore to estimate the regional differences in the firms' average production depending on the average use of private inputs and the total public inputs available at the regional level. This will provide estimations of the average total factor productivity of the firms in the region and can be applied with the usual data available in the literature. The only special requirement is to have information about the regional stock of firms.

Furthermore, the paper argues that most of the entrepreneurship capital measures used previously by the literature are defined, or can be mathematically related with the stock of firms. For example, the firms' regional stock is the sum of such stock in the different economic sectors that it is composed of, or is the sum of the annual increases (or decreases). So it can be empirically tested whether those measures provide further information than the stock of firms. Throughout the text we provide some discussion of how to test that.

This paper provides a first application of those developments in a data sample covering the 52 provinces into which Spain is administratively divided (NUTS 3 Eurostat) in the 2002-2012 period with information as close as possible to that used in the previously cited literature. Although studies have analyzed the economic impact of entrepreneurship capital in Spain (Salas-Fumás and Sánchez-Asín, 2008, 2010, 2013a & 2013b; Callejón, 2009; Callejón and Ortún, 2009), these use other methodological approaches and aggregate data referring to the Autonomous Communities (NUTS 2 Eurostat) into which provinces are grouped. As the effects of entrepreneurship capital seem to be stronger at the local level, smaller regional divisions are preferred when data is available.

The data is analyzed with and without our methodological contributions. In this case, there are major differences in the interpretation of the results and conclusions. Obviously we cannot make assertions regarding what will happen (or what would have happened) in other contexts, but a priori, future research cannot reject the idea that there may be decreasing returns to scale, which has to be corrected for. The paper provides a simple methodological framework for making such corrections.

The paper is organized as follows. First, the previous literature is summarized. Second a theoretical framework is developed to understand the interpretation of the evidence made in the previous empirical literature and discuss the methodological contributions proposed in this literature. Third, the empirical approach is presented, which is summarized in the form of different hypotheses. Fourth, the sectorial decomposition is analyzed. After that, the data and variables used in testing the hypotheses are described. Finally, we present the results and discuss the paper's implications.

2 Regional entrepreneurship capital and production: Literature review

Since Audretsch and Keilbach (2004a), several authors have suggested that entrepreneurship capital is a public input on a regional level. Their arguments are based on previous literature analyzing the influence of knowledge, measured in terms of human capital (Romer, 1986) or investments in research and development (Jones, 1995), on regional production. Knowledge could be generated in different institutions, such as universities, scientific parks or in-company research centres, among others. Acs et al., (2009) argue in favour of the knowledge spillovers of entrepreneurship. Filters exist between knowledge and its commercialization. This knowledge is not always directly useful for production activities. So, among other filters there is a need for people to find ways of using the knowledge to produce commercial goods. Most or some of these people will be entrepreneurs. The capacity of a region to generate such entrepreneurial activity, in short term entrepreneurship capital, will affect their production. From this starting point, a growing amount of literature is estimating the effects of regional entrepreneurship capital on a region's production.

The measurement and concept of entrepreneurship capital generates some discussion (Erikson, 2002; Audretsch, 2009; Bönte et al., 2008) as the measurement of whatever other kind of input. For example, the empirical applications work with different measures that go from the stock of firms in the region (Stough et al., 2008), to the entry rate of firms in key industries (Chang, 2011). Audretsch and Keilbach (2004a,b & 2008) used the annual average of new firms per 1,000 workers created in a three year period.

Mueller (2006 & 2007) also uses this indicator along with the number of new firms created in one year. Sutter and Stough (2009) use the average number of technological and innovative firms created in the last five years; while Bönte et al., (2008), Salas-Fumás and Sánchez-Asín (2008, 2010, 2013a & 2013b) and Stough et al., (2008) use the self-employment rate on a regional level. All of those entrepreneurship capital measures are part of (and can therefore be related with) the number of firms in the region.

To estimate the impact of regional entrepreneurship capital on the production for region i and period t, $Y_{i,t}$, the usual method is to follow Solow (1956) by summarizing private inputs as capital ($K_{i,t}$) and labour ($L_{i,t}$) and summarizing public inputs as knowledge ($R_{i,t}$) and entrepreneurship capital ($E_{i,t}$). The output obtained as a combination of those private and public inputs is estimated in most cases by Cobb-Douglas (1928) functions:

$$\ln Y_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln K_{i,t} + \beta \ln L_{i,t} + a_i + \varepsilon_{i,t} \qquad (1)$$

Hence, the parameters to be estimated are the production elasticity with respect to capital (α), labour (β), entrepreneurship capital (δ) and knowledge (μ). Studies with panel data can control for the regional fixed effects (a_i), and are the usual error terms, following independent and identical normal distributions. When it is assumed that production technologies present constant returns to scale for private inputs ($\beta = 1 - \alpha$) the production per employee ($y_{i,t} = Y_{i,t}/L_{i,t}$) will be:

$$\ln y_{i,t} = \ln Y_{i,t} - \ln L_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln k_{i,t} + a_i + \varepsilon_{i,t} \qquad (2)$$

where ($k_{i,t} = K_{i,t}/L_{i,t}$). The above production function has been estimated in several studies using one method (2) (Audretsch and Keilbach, 2004a) or another (1) (Audretsch and Keilbach, 2004b; Audretsch et al., 2008; Mueller, 2006 & 2007; Bönte et al., 2008; Stough et al., 2008). In all the studies estimating Equation (1), with the exception of Audretsch and Keilbach (2004b), are decreasing returns to scale ($\alpha + \beta < 1$), although only Mueller (2006) reports a test of their significance. In their estimations, the elasticity of production with respect to knowledge (μ) and entrepreneurship capital (δ) are positive and statistically significant.

The theoretical arguments interpreting entrepreneurship capital as a public productive input suggest that their sectorial composition could be relevant. As much of the entrepreneurial activity is related with the newness of the knowledge applied, its impact on the regional production has to be higher when the entrepreneurship activity is concentrated in more knowledge intense economic sectors. To test this, Audretsch and Keilbach (2004a,b,c & 2008) classified entrepreneurship capital on the basis of the technological intensity of the sectors: high technology, ICT's, and other sectors. They have considered them as alternative measures of entrepreneurship capital. Although in all cases production elasticity with respect to entrepreneurship capital is positive and significant, the highest one is that associated with the less technological sectors, other sectors. Mueller (2006 & 2007) finds that production elasticity with respect to knowledge generated in industry is greater than the elasticity with respect to knowledge generated in universities or public research centres. In terms of geographical location, the elasticity of production with respect to entrepreneurship capital in urban zones is higher than in rural ones (Audretsch and Keilbach, 2005).

Much of this literature provides isolated estimations of Equations (1) and (2). Obviously, production is just one part of an economy. The destination of regional production is consumption and most of the current inputs have to be produced in the past. So although there is no interest in analyzing the uses of the production or the origins of the inputs, when inputs and outputs are not properly measured, they could affect the parameters estimated and their interpretation.

For example, if there is a shock at the regional level that affects production in one period, $Y_{i,t-1}$, it will affect the consumption levels of some goods in the next period $X_{i,t}$. Let us assume that the shock also affects the production of the next period. Then, $Y_{i,t}$ and $X_{i,t}$ will be correlated, although the latter has not been used for production in period t. Then, some of the parameters estimated can suffer reverse causality. Furthermore, production theoretically precedes consumption, but with annual data at the regional aggregate level it is difficult to distinguish between them. Audretsch and Keilbach (2008) used simultaneous equation procedures to capture the simultaneity of different economic relationships. Even in this case, it has not been analyzed the implications of the fact that regional production is the aggregation of the firms' production in the region on the interpretation of the elasticity of regional production with respect to entrepreneurship capital. Such problems with the interpretation of the parameters are detailed in the next section.

3 Aggregating the firms' production functions at the regional level

The reviewed literature can be considered a stream of a broader literature on the determinants of regional production (Solow, 1956; Romer, 1986). Although regional production is the aggregation of firms' production in the region, this literature makes some simplifying assumptions in order to use data on the aggregated level. We will argue that when research seeks to determine the role of entrepreneurship capital as a public good in the economy, such assumptions are not as innocuous as they could be for other research purposes. To do so, consider $Y_{i,t}$ as the aggregation of the production of the $n_{i,t}$ firms operating in the region i during period t. Define $Y_{i,t,j}$ as the production of firm j in region i during period t. In algebraic terms:

$$Y_{i,t} = \sum_{j=1}^{n_{i,t}} Y_{i,t,j} = n_{i,t}\overline{Y}_{i,t} \text{ where } \overline{Y}_{i,t} = \sum_{j=1}^{n_{i,t}} (Y_{i,t,j}/n_{i,t}) \quad (3)$$

Firm j can use a set of private inputs purchased on the market. To reduce notation and be consistent with previous literature consider only capital $K_{i,t,j}$ and labour $L_{i,t,j}$ as private inputs. The following function summarizes the relationship between the production and inputs used:

$$Y_{i,t,j} = TFP_{i,t,j} f(K_{i,t,j}, L_{i,t,j}) + v_{i,t,j} \quad (4)$$

where f is the function that relates private inputs with production, $TFP_{i,t,j}$ is the total factor productivity of the firm and $v_{i,t,j}$ an error term. The total factor productivity can be expressed as a function of the set of public inputs available for all the firms and inhabitants of region i. Following previous literature consider entrepreneurship capital and knowledge to be the available public inputs $TFP_{i,t,j} = TFP_{i,t}e^{a_i}g(R_{i,t}, E_{i,t})$. Function g captures the effect of public inputs or goods on the total factor productivity of firms. Then, the total factor productivity will be the same for all the firms in the same region and will differ among regions by the parameter a_i. The error term has an expected value of 0, all the shocks are assumed to be uncorrelated with each other and with the inputs.

The estimation of the regional production by equations (3) and (4) requires information about the level of output and private inputs used by all the firms in the region. This would be extremely demanding in terms of data. With aggregate data at the regional level, an approximation to each firm output and private inputs is the firm average for this region, $\overline{Y}_{i,t}$, $\overline{K}_{i,t} = \sum_{j=1}^{n_{i,t}}(K_{i,t,j}/n_{i,t})$ and $\overline{L}_{i,t} = \sum_{j=1}^{n_{i,t}}(L_{i,t,j}/n_{i,t})$. So we can rewrite equations (3) and (4) as follows:

$$Y_{i,t} = n_{i,t}\overline{Y}_{i,t} \tag{5}$$

$$\overline{Y}_{i,t} = e^{a_i}g(R_{i,t}, E_{i,t})f(\overline{K}_{i,t}, \overline{L}_{i,t}) + v_{i,t} \tag{6}$$

where $v_{i,t} = \sum_{j=1}^{n_{i,t}}(v_{i,t,j}/n_{i,t})$. This approach can easily be implemented, but we have not found estimations of Equation (6) in the reviewed literature. To compare this approach with the usual method, assume that function f is homogenous of degree θ, so: $f(\overline{K}_{i,t}, \overline{L}_{i,t}) = n^{-\theta}f(K_{i,t}, L_{i,t})$, then from equations (5) and (6) we can obtain:

$$Y_{i,t} = n_{i,t}^{1-\theta}e^{a_i}g(R_{i,t}, E_{i,t})f(K_{i,t}, L_{i,t}) + v_{i,t} \tag{7}$$

In short, given two regions with an equal level of private inputs, $(K_{i,t}, L_{i,t})$, the region with a higher number of firms $(n_{i,t})$ could be more productive for two reasons. First, the firms are smaller (in terms of the private inputs used) and the production has decreasing returns to scale ($\theta < 1$). Second, the number of firms is a proxy or a measure of a public good $E_{i,t}$. In fact, the reviewed literature considers the second to be the only possible explanation. Implicitly they are assuming that $\theta = 1$:

$$Y_{i,t} = e^{a_i}g(R_{i,t}, E_{i,t})f(K_{i,t}, L_{i,t}) + v_{i,t} \tag{8}$$

Assuming that the error terms $v_{i,t}$ follow a lognormal distribution, $g(R_{i,t}, E_{i,t}) = R_{i,t}^{\mu}E_{i,t}^{\delta}$ and $f(K_{i,t}, L_{i,t}) = K_{i,t}^{\alpha}L_{i,t}^{\beta}$, so f is homogenous of degree $\theta = \alpha + \beta$, we obtain Equation (1). In short, the relationship between entrepreneurship capital and production has been interpreted in the reviewed literature in terms of its effect as a public good, neglecting the effect of returns to scale. Then, one could argue that the main empirical contribution of this literature is to suggest that, in terms of regional production, not only is the level of private inputs used at the regional level important, but the number of firms among which they are distributed is also relevant. Regions with a higher number of firms (smaller average firm size in terms of inputs) will be more productive. We genuinely believe that this is an important contribution.

The shortcoming is that it can reflect how (i) there are decreasing returns to scale and/or (ii) the number of firms affects the total factor productivity of the firms in the region. Assume that there are decreasing returns to scale and the entrepreneurship capital measure is positively correlated with the stock of firms. Then, the elasticity of production with respect entrepreneurship capital estimated using Equation (1), provides biased estimations (overestimate) the effects of entrepreneurship capital in the total factor productivity of the firms in the region.

Our proposal is to look in more depth at these two possible causes: there are decreasing returns to scale or the number of firms affects the total factor productivity of the firms in the region. A priori we do not know which is the case, and it could in fact vary among studies. In accordance with the discussion in this section, it will depend on the importance of returns to scale and the correlation between the entrepreneurship capital measure and the number of firms. In fact, this is an empirical query and the discussion above suggests a methodological benchmark for addressing it. The estimation of Equation (6) is a first and easy step for advancing in this direction. This only requires information about the stock of firms, which is available in most of the studies reviewed in the section above. We will provide some evidence in this regard. The following section describes and discusses how we will proceed in more detail.

4 Proposals and hypotheses

Obviously, one alternative is to find a measure of entrepreneurship capital that is not correlated with the stock of firms. Then, the discussion in the section above is irrelevant. Our point is that it is very difficult to obtain measures of entrepreneurship capital that are not related with the number of firms in the region. Furthermore, this is not necessary in order to solve the problem. So this is not a problem with measuring entrepreneurship capital, it is a problem with the estimation procedure, which is solved by estimating Equation (6). To compare with the existing literature we propose estimation of the following version of Equation (6):

$$\ln \overline{Y}_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln \overline{K}_{i,t} + \beta \ln \overline{L}_{i,t} + a_i + \varepsilon_{i,t} \tag{9}$$

Equation (1) and Equation (9) can provide different estimations of parameter δ. To differentiate between them, we will refer to as δ_{CRS} the parameter estimated by Equation [1], and δ the estimated by Equation (9). In accordance with the discussion in the section above, when there are constant returns to scale, all the coefficients estimated by these two equations will be the same ($\delta_{CRS} = \delta$). So a first step is to test for the presence of returns to scale.

Hypothesis 1 *Technologies present constant returns to scale* ($\beta + \alpha = 1$).

When this hypothesis is rejected, the parameters estimated by both equations will differ. In fact, using the stock of the firms in the region ($n_{i,t}$) as the measure of the entrepreneurship capital will clarify the debate. In this case, the parameters estimated by Equation (1) and (9) are going to be the same, except the elasticity of production with respect the entrepreneurship capital, δ_{CRS} and δ respectively. A positive value of δ_{CRS} means that given a certain level of private inputs, those regions with more firms (which will also be those with a smaller average firm size measured in terms of inputs) are more productive. The question is why, and Equation (9) helps to start looking for an answer, ($\delta_{CRS} = 1 - \alpha - \beta + \delta$). It could partly be due to the stock of the firms in the region affecting the total factor productivity of these firms ($\delta > 0$), as the entrepreneurship capital literature suggests. We can test this.

Hypothesis 2 *Firm production in a region is positively related with the regional entrepreneurship capital (*$\delta > 0$*).*

Another answer could be the fact that the average firm size is smaller (in terms of the private inputs used) and the production has decreasing returns to scale ($1 - \alpha - \beta + \delta > 0$). Decreasing returns to scale is a common assumption in microeconomic literature focused on the determinants of firm size (Rosen, 1982; Garicano, 2000; Ortín and Salas, 2002). Those theoretical models usually assume that firms maximize profits and behave in competitive markets; output and input prices are parametric. Then, to obtain a single interior solution, the production function must present decreasing returns to scale. Furthermore, those models assume that firms differ in their total factor productivity.

In fact, the total factor productivity has been interpreted in this literature as the talent of the entrepreneur (or the manager when entrepreneurs are not in charge of the firm).

Let us introduce such arguments to the theoretical benchmark of Section 3. For that purpose, to the total factor productivity of one firm $TFP_{i,t,j}$ considered in the section above constant for all the firms in one region, $TFP_{i,t}$, we add a new term specific to each firm representing the talent of the entrepreneur, $TFP_{i,t,j} = TFP_{i,t} \times TFP_{t,j}$. When more talented entrepreneurs start and manage bigger firms, then $TFP_{t,j}$ is positively correlated with the size of the firm. Leung et al., (2008) or Castany et al., (2005) provide evidence in this regard. We can now express the logarithmic version of Equation (6) or Equation (9) as:

$$\ln \overline{Y}_{i,t} = \ln \overline{TFP}_{i,t} + \alpha \ln \overline{K}_{i,t} + \beta \ln \overline{L}_{i,t} + \varepsilon_{i,t} \tag{10}$$

where $\ln \overline{TFP}_{i,t} = \ln TFP_{i,t} + \sum_{j=1}^{n_{i,t}} (\ln TFP_{t,j}/n_{i,t}) = \mu \ln R_{i,t} + \delta \ln E_{i,t} + a_i$. Purely for expositional purposes let us redefine $\ln TFP_{i,t}$ as $\ln TFP_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + a_i$. In Section 3 we were assuming that ($\delta = \delta_P$), but the literature relating total factor productivity and the size of the firm suggests that this may not be the case.

After controlling for the level of inputs, those regions with more firms will have on average smaller firms and lower total factor productivity. Purely for explanatory purposes, let us assume that $\sum_{j=1}^{n_{i,t}} (\ln TFP_{t,j}/n_{i,t}) = \delta_A E_{i,t}$. So this stream of literature predicts that the value of parameter δ_A will be negative. In fact, from Equation (9) we cannot distinguish which is the prevalent interpretation of the relationship between total factor productivity and entrepreneurship capital ($\delta = \delta_P + \delta_A$), the role of entepreneurship capital as a public good ($\delta_P > 0$) or differences in total factor productivity between firms of different size ($\delta_A < 0$). Note that $\delta < 0$ could be consistent with the evidence described in Section 2 ($\delta_{CRS} > 0$), always that: $1 - \alpha - \beta > -\delta > 0$. Disaggregate information at the firm level could help to distinguish between these two explanations. With regional aggregate data we can only estimate δ.

5 Sectorial entrepreneurship capital

The rejection of Hypothesis 2 can cast doubts on the economic importance of the role of regional entrepreneurship capital as a public good, but its rejection will not imply that the entrepreneurship capital of some concrete economic sectors is not economically relevant. Then, it is interesting to test whether the sectorial composition of the entrepreneurship capital will matter, as the theoretical arguments in Section 2 suggest.

Hypothesis 3 *The decomposition of entrepreneurship capital into economic sectors is irrelevant for the regional firm's production.*

To test Hypothesis 3 and for notational consistency, we define $E1_{i,t}$ as the $E_{i,t}$ logarithmic transformation, $E1_{i,t} = \ln E_{i,t}$. In fact, both can be interpreted as measures of entrepreneurship capital. Let us identify by $E_{i,t,s}$ the entrepreneurship capital of economic sector s. We can relate the entrepreneurship capital of the different economic sectors (s= 1,. . . ,S) with the entrepreneurship capital at the regional level by: $\sum_{s=1}^{S} E_{i,t,s} = E1_{i,t} \sum_{s=1}^{S} p_{i,t,s}$, where $p_{i,t,s} = E_{i,t,s}/E1_{i,t}$ is the proportion of entrepreneurship capital in sector s over the total in this region i. Let us define $b_{i,t} = \sum_{s=1}^{S} p_{i,t,s} - 1$ so $\sum_{s=1}^{S} E_{i,t,s} = (1 + b_{i,t})E1_{i,t}$. For example, if the entrepreneurship capital is measured by the number of firms, $E1_{i,t} = n_{i,t} = \sum_{s=1}^{S} n_{i,t,s} = \sum_{s=1}^{S} E_{i,t,s}$, then $\sum_{s=1}^{S} p_{i,t,s} = 1$ and consequently $b_{i,t} = 0$. But, as argued in Section 2, entrepreneurship capital is usually introduced to equations in logarithmic terms (Cobb-Douglas functions). Then, $E1_{i,t} = \ln n_{i,t} = ln(\sum_{s=1}^{S} n_{i,t,s})$. In the case that $E_{i,t,s} = \ln n_{i,t,s}$, $\sum_{s=1}^{S} p_{i,t,s} \neq 1$ so $b_{i,t} \neq 0$ and $\sum_{s=1}^{S} E_{i,t,s} \neq E1_{i,t}$. In these cases ($b_{i,t} \neq 0$), and to ensure that the sum of the sectorial entrepreneurship capital is equal to the aggregate one, we propose the use of: $E1_{i,t,s} = E_{i,t,s}/b_{i,t}$, so always $\sum_{s=1}^{S} E1_{i,t,s} = E1_{i,t}$ and $b1_{i,t} = \sum_{s=1}^{S} p1_{i,t,s} - 1 = 0$, where $p1_{i,t,s} = E1_{i,t,s}/E1_{i,t}$. To Test Hypothesis 3 we propose estimating:

$$\ln \overline{Y}_{i,t} = \mu \ln R_{i,t} + \delta_S E1_{i,t} + \sum_{s=1}^{S-1} (\delta_s - \delta_S) E1_{i,t,s} + \alpha \ln \overline{K}_{i,t} + \beta \ln \overline{L}_{i,t} + a_i + \varepsilon_{i,t} \tag{11}$$

Therefore Equation (9) is a special case of the above equation, where $\delta_s = \delta_S$ for all sectors s. Hypothesis 3 implies testing for such restrictions. In fact, some previous papers (Audretsch and Keilbach, 2004a,b,c & 2008) have used the logarithm of sectorial measures of entrepreneurship capital. They consider these to be alternative measures of entrepreneurship capital. This implies the assumption that $b_{i,t} = 0$ and only the entrepreneurship capital of one economic sector has an economic impact, $\delta_s > 0$, imposing for the remaining sectors –*s*, $\delta_{-s} = 0$.

Let us refer to $\overline{\delta}_s$ as the parameter estimated by Audretsch and Keilbach's (2004a,b,c & 2008) procedure, and δ_s the one estimated using Equation (11). Let us assume that we are in a situation where the sectorial decomposition is irrelevant ($\delta_s = \delta_S$ for all *s*) and the weight of sector *s* is constant among regions and time, $p1_{i,t,s} = p1_s < 1$. It is easy to check that $\overline{\delta}_s = \delta_s / p_s$ given that $E1_{i,t,s} = p_s E1_{i,t}$. So in this case the estimated parameter $\overline{\delta}_s$ for sector *s* entrepreneurship capital will be higher than the one estimated for the aggregate entrepreneurship capital δ even when there are no real differences between the parameters ($\delta_s = \delta_S$ for all *s*). We will compare the estimations made by one and the other procedure.

Audretsch and Keilbach (2004a,b,c & 2008) classified entrepreneurship capital on the basis of the technological intensity of the sectors: high technology; ICT's; and the remaining sectors. For that purpose we can order the economic sectors from the most to the least technologically intensive (*s=1,2,3*). Their theoretical arguments suggest that $\delta_1 > \delta_2 > \delta_{S=3}$ as summarized in the following hypothesis:

Hypothesis 4 *The effect of the regional entrepreneurship capital of one economic sector on firms' production is positively related with its technological base.*

The interpretation of the parameters δ_s estimated by Equation (11) has similar problems to that detected in the section above related to the parameter δ estimated by Equation (9). Equation (11) can be interpreted as a special case of Equation (10) where now $\ln \overline{TFP}_{i,t} = \ln TFP_{i,t} + \sum_{j=1}^{n_{i,t}} (\ln TFP_{t,j} / n_{i,t}) = \mu \ln R_{i,t} + \delta E1_{i,t} \sum_{s=1}^{S} (\delta_s / \delta) p1_{i,t,s} + a_i$. Entrepreneurship capital has a scale effect, δ estimated in Equation (9), and a sectorial composition effect, δ_s estimated in Equation (11) by the introduction of $p1_{i,t,s}$. Previous literature (Audretsch and Keilbach 2004a,b,c & 2008) is silent about $\sum_{j=1}^{n_{i,t}} (\ln TFP_{t,j} / n_{i,t})$, or in other words has assumed that it is null and has interpreted the evidence in terms of $\ln TFP_{t,j} / n_{i,t}$. Baumol (1990) suggests that the emphasis on the development of economic activity in certain specific economic sectors could accelerate or reduce the economic growth of a certain region. So the total factor productivity of the region could depend on the weight of the different economic sectors. Purely for explanatory purposes let us assume that $TFP_{t,j} = e^{a_s}$ where a_s as is the total factor productivity of sector s to which the firm belongs, in this case: $\sum_{j=1}^{n_{i,t}} (\ln TFP_{t,j} / n_{i,t}) = \sum_{s=1}^{S} \ (a_s n_{i,t,s} / n_{i,t}) = \sum_{s=1}^{S} \ a_s p1_{i,t,s}$

where $p1_{i,t,s} = n_{i,t,s}/n_{i,t}$. In this case the sectorial composition is also expected to affect the total factor productivity. Disaggregate data at the sectorial level would allow us to distinguish between both explanations. Like the reviewed literature we do not have this disaggregation. Then, differences in δ_s could be explained because the entrepreneurship capital in some sectors is more productive, or due to differences in the total factor productivity of the firms in one sector.

6 Data and Variables

The empirical section provides estimations of Equation (11), where the dependent variable is the firms' average year production in one region. Consequently, the private inputs used will also be the firms' averages for the region. Sure that the equations estimated are not fully capturing all of the economic relationships that affect these variables, and consequently possible sources of endogeneity. But given the current evidence and theoretical debate it is difficult to figure out the nature of those relationships or sources of endogeneity. We created panel data covering an eleven-year period from 2002 to 2012 (t = *1,...,11*), for the 52 Spanish provinces (i= *1,...,52*), a total of 572 observations. This could at least enable us to control for regional fixed effects, shocks that affect the regional firms' average production in all the years observed.

The output and inputs considered, and their measures, are as similar as possible to those used in the reviewed literature. As in many other countries, Spanish public and private institutions have made major efforts to provide internationally homogenous (i.e. EU-KLEMS project) measures of the labour and the physical capital used each year to obtain the regional output. We collected this information from different sources.

The regional aggregate output is measured by the *Gross Value Added* ($Y_{i,t}$). The Spanish National Statistics Institute (INE) generates periodically disaggregated information at the provincial level of the annual value of the production of goods and services minus intermediate consumption. Like all the other monetary variables, it will be expressed in constant million euros for the year 2000.

The BBVA Foundation and the Valencian Institute of Economic Research (BBVA-IVIE) is a well-known research institute that following the EU-KLEMS methods provides monetary values of the set of assets accumulated in each province, *Capital Stock* ($K_{i,t}$). This information has been widely used in studies related with the Spanish economy.

Labour ($L_{i,t}$) is measured by the number of employees engaged in production activities in each province. It is derived from the Economically Active Population Survey (EAPS), which is periodically produced by the INE.

The stock of firms ($n_{i,t}$) is required to compute firms' average production and average private inputs. This information is available from the Central Business Register (DIRCE) database. This is the only variable with information disaggregated for the economic sectors defined according to the NACE 1999 classification. Based on the methodologies developed by the Organization for Economic Cooperation and Development (OECD) and EUROSTAT, the INE classifies the economic sectors in accordance with their technological intensity. They define technology sectors as the ones characterized by rapid knowledge renewal and that require a continuous and concerted effort to foster research and technological foundation. Somewhat consistent with previous classifications in the literature, we ultimately work with three sectors; very high tech service sectors (HT or $s = 1$), high and medium tech manufacturing sectors (MT or $s = 2$), and the remaining sectors ($s = 3$) which is the sector omitted from the regressions. Table 1 identifies the specific sectors in each category.

The number of firms ($n_{i,t}$) in one region can be considered a measure of the *Entrepreneurship Capital* ($E_{i,t}$) of this region. Entrepreneurship capital has also been measured in previous literature as the regional variation rate in the number of firms. By definition, the number of firms is the sum of all the flows accumulated over time. So the question is whether recent flows play a different role to older ones. For that purpose we define the rate of firms created in province i during the previous period as t: $\phi_{i,t} = n_{i,t}/n_{i,t-1} - 1 = (n_{i,t} - n_{i,t-1})/n_{i,t-1}$. In this case, $n_{i,t} = (1 + \phi_{i,t})n_{i,t-1}$ and consequently, $\ln n_{i,t} = \ln(1 + \phi_{i,t}) + \ln n_{i,t-1}$. In fact it is possible to introduce to Equation (11):

$$\delta \ln E_{i,t} = \delta_F \ln(1 + \phi_{i,t}) + \delta_T \ln n_{i,t-1} = \delta_F \ln n_{i,t} + (\delta_T - \delta_F) \ln n_{i,t-1} \qquad (12)$$

and interpret Equation (11) as a special case that imposes $\delta_F = \delta_T$; the variation rate is not informative. This could be empirically tested, as $\delta_T = 0$, the stock does not add more information than that provided by the variation rates. In short, the number of firms is needed to estimate Equation (11). In most cases it is used to define a measure of entrepreneurship capital. Then, the assumption that this measure provides additional information to that provided by the stock of firms can be empirically tested.

Following Bönte et al., (2008), *Knowledge* ($R_{i,t}$) is measured by the number of patents filed each year based on the data available on a provincial level in the SPTO. We will not have access to other proxies at the regional level used before, such as, for example: the number of people employed in private companies or universities in areas related to R&D (Mueller, 2007) and the annual R&D costs (Griliches, 1998). Table 2 presents descriptive statistics of the variables.

7 Results

Table 3a provides estimations of Equation (11). The different columns differ in terms of the independent variables used in the estimations, or in other words, the different restrictions imposed on the parameters of the equation. In order to compare the results with previous methods used in the literature, Table 3b provides estimations of comparable versions of Equation (1). As discussed in Section 4, note that Model 1 and 2 only are going to differ in the estimation of the elasticity of production with respect the entrepreneurship capital.

Following the econometric literature on data panels; the group model, the fixed effects model and the random effects model have been estimated for all the equations. Results referred to hypotheses are maintained. For expositional simplicity we only provide the estimations of the fixed effects model because, the Breush and Pagan (1979) and Hausman (1978) tests indicate that this is the most appropriate method for modelling the non-observable heterogeneity among provinces in the sample analyzed[1]. The error terms of all the estimated equations are robust to heteroskedasticity and clustered by provinces.

Table 3a shows estimations of the elasticity of production with respect to knowledge (μ) between 0.098 and 0.012, positive and statistically significant at 1%. The elasticity of production with respect to capital (α) takes values between 0.1804 and 0.2170 and the elasticity with respect to labour (β) between 0.1875 and 0.2126, all these parameters being statistically significant at the 1% level. These values indicate that the production technology presents decreasing returns to scale ($\alpha + \beta < 1$), so Hypothesis 1 is rejected

[1] This and all the other estimations cited in the paper but which do not appear in the text can be provided upon request to the authors.

at the usual levels of significance[2].

Model 1 presents the estimation of Equation (11) (Table 3a) and the estimation of Equation (1) (Table 3b) assuming that the sectorial decomposition is irrelevant. Consistent with the rejection of Hypothesis 1, the elasticity of production with respect to entrepreneurship capital (δ_{CRS}) estimated by Equation (1) is higher than the one estimated (δ) by Equation (11). Equation (1) (Table 3b) shows that those regions with (on average) smaller firms (measured in terms of inputs) are more productive. After controlling for the level of private inputs, those regions with 1% more firms, produce, on average, 0.3357% more. The parameter (δ_{CRS}) is statistically significant at the 1% level. In our case, the main explanation for those effects is the existence of decreasing returns to scale ($1 - \alpha - \beta$ = 0.5704). In fact, according to Equation (11) (Table 3a), the productivity of the average firm decreases by a percentage of 0.2347% [$\delta = \delta_{CRS} - (1 - \alpha - \beta) =$ –0.2347] for each 1% increase in the number of firms in the province. The parameter is statistically significant at the 1% level. So Hypothesis 2 is not supported by the data.

Adding to Model 1 the stock of firms lagged one year (in logarithmic terms), we obtain Model 2. In this case we lose the 52 observations for 2002. Regardless of the equation estimated (Table 3a or Table 3b), the coefficient associated to this lagged variable is 0.0496, positive but not statistically significant at the usual levels. So in our case the flow of firms does not provide new statistically significant information ($\delta_T - \delta_F$= 0.0496). Focusing on Equation (11) (Table 3a) the effect estimated for the flow of firms in the previous year (–0.2605=δ_F) is even more negative than the one associated with the stock of firms (–0.2109=δ_T). As commented earlier, the differences to the coefficients estimated by Equation (1) (Table 3b) are due to the presence of decreasing returns to scale.

Model 3 in Table 3a provides estimations of Equation (11) including the sectorial decomposition of the stock of firms. The coefficients associated with the stock of firms in the two technological sectors considered are positive and statistically significant at the usual levels of significance. So Hypothesis 3 (the sectorial decomposition is irrelevant) is rejected in this case.[3]

Furthermore, the estimated elasticity of production with respect to the number of firms in very high tech services sectors (δ_1 = –0.1625) is higher than the one associated

[2]The null hypothesis that $\alpha + \beta = 1$ is rejected at the 1% level in all equations.

[3]The null hypothesis that $\delta_1 = \delta_2 = \delta_3$ is rejected in all cases at 1% of significance.

with high and medium tech manufacturing firms (δ_2 = –0.4019) and other sectors (δ_3 = –0.5207). Although not provided in the table, all those elasticities remain negative and statistically significant at 1%. In fact, the differences in the parameters are all statistically significant at the 5% level. So the data supports Hypothesis 4.

Model 3 in Table 3b estimates the elasticity of production with respect to the number of firms in very high tech services sectors using similar econometric procedures to the previous literature (Audretsch and Keilbach, 2004a,b,c & 2008). The results are consistent with those obtained previously in the literature. As opposed to Table 3a, the elasticity of production with respect to the number of firms in very high tech services sectors will now be positive and lower than that estimated for the general number of firms.

8 Conclusions and discussion

After controlling for the level of inputs used, in those regions with a higher number of firms, the average size of those firms will be smaller (in terms of the inputs used). From a theoretical point of view, these regions can be more productive for at least two reasons, because there are decreasing returns to scale or due to the fact that the number of regional entrepreneurs produces positive externalities. We argue that previous literature on entrepreneurship capital has not properly distinguished between both effects, so the previous evidence has only been interpreted in terms of positive externalities.

The paper presents a methodology to help to distinguish between both effects. The methodology is simple; it can be applied with data aggregated at the regional level and only requires information about the number of firms in the region. This is a starting point for analyzing the sources of differences in productivity between regions as detected previously by the entrepreneurship capital literature.

Note that the methodology proposed is not about the measure of the entrepreneurship capital used, it is about the kind of equations estimated. The methodology suggests that the number of firms has to be used in order to control for the existence of returns to scale, but it does not claim to be the best measure of entrepreneurship capital. Even if there is a measure of entrepreneurship capital that is not related with the number of firms, then the suggested methodology will provide similar estimations of the elasticity of production with respect to entrepreneurship capital to those of traditional ones. A second order methodological contribution is to suggest that most of the measures of entrepreneurship capital used in the literature can be formally related with the number of firms. So we can make explicit the assumptions that make one measurement different from the other and test it empirically. In particular, we demonstrate the procedure with sectorial measures of entrepreneurship capital and with the variation rate in the number of firms. But it could be applied to other measures.

We provide evidence related with all these aspects in a data sample of Spanish provinces in the 2002-2012 period. In accordance with the estimations presented, production technologies present decreasing returns to scale in the use of private inputs; labour and capital. This seems to be the norm, and not the exception in the literature reviewed. In this paper, this is the main explanation for the estimated positive relationship between the stock of firms and production at the regional level.

According to our estimations, the total factor productivity of firms is lower in those regions with a higher stock of firms. Unfortunately we cannot check exactly what would have happened in past studies if we had made such corrections. It is even difficult to reproduce the exact measures of entrepreneurship capital that were used before. Instead of the stock of firms, we employed the variation rate in the number of firms and the stock of firms in different economic sectors. The above conclusion is robust to all these alternative measures. In fact, only the division of the stock of firms into economic sectors is statistically significant.

The evidence provided cannot be understood as evidence against the knowledge spillover theory of entrepreneurship (Acs et al., 2009). This is merely a preliminary warning that the role of entrepreneurship capital as a public good in regional economies may be overestimated when we do not correct for decreasing returns to scale. In fact, the evidence concerning the sectorial decomposition of the stock of firms seems consistent with the prediction of the cited theory. In regions where proportionally more firms are related with technological sectors, the average total factor productivity of the firms in the region increases.

The methodology proposed does not address other relevant issues concerning the reviewed entrepreneurship capital literature, such as the measurement of inputs or reverse causality problems. As discussed in the theoretical sections, without information that has been disaggregated at the firm level, it is difficult to distinguish between the effect of public goods or the existence of correlations between the size of firms and their total factor productivity. Our conjecture is that the latter is the most plausible explanation for the negative relationship between the stock of firms and production after controlling for returns to scale. Large firms have higher total factor productivity levels as some theoretical models (Rosen, 1982; Garicano, 2000; Ortín and Salas, 2002) and empirical evidence (Leung et al., 2008; Castany et al., 2005) suggest. There is therefore a need for further evidence with information disaggregated at the firm level to distinguish between both explanations. Furthermore, regional information disaggregating outputs and inputs at the sectorial level will be valuable for distinguishing between the effects of sectorial entrepreneurship capital and the effects of differences in the total factor productivity among economic sectors. The proposed methodology can easily be adapted to this kind of information. Indeed, it can be extended to the consideration of new theoretical or empirical relationships that have not been explored in this study. Theoretical developments can improve our understanding of the relationships between the different inputs and outputs measured. In future empirical studies, it would be useful to control for such sources of endogeneity.

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Table 1. Technological Sectors - INE

NACE	Sectors		
72	Scientific research and development		*s=1*
	721 Research and experimental development on natural sciences and engineering		*s=1*
	722 Research and experimental development on social sciences and humanities	Very high	*s=1*
59	Motion picture, video & TV production, sound recording & music publishing act.	tech services	*s=1*
60	Programming and broadcasting activities	sectors	*s=1*
61	Telecommunications	[HT]	*s=1*
62	Computer programming, consultancy and related activities		*s=1*
63	Information service activities		*s=1*
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations		*s=2*
26	Manufacture of computer, electronic and optical products		*s=2*
	303 Manufacture of air and spacecraft and related machinery	High & medium	*s=2*
20	Manufacture of chemicals and chemical products	tech	*s=2*
25	Manufacture of fabricated metal products, except machinery and equipment	manufacturing	*s=2*
27	Manufacture of electrical equipment	sectors	*s=2*
29	Manufacture of motor vehicles, trailers and semi-trailers	[MT]	*s=2*
30	Manufacture of other transport equipment		*s=2*
	325 Manufacture of medical and dental instruments and supplies		*s=2*
	Remaining sectors	[NT]	*s=3*

Source: INE [http://www.ine.es/daco/daco43/notaiat.pdf]

Table 2. Descriptive Statistics

Variable	Mean	Standard Deviation
$\ln Y_{i,t}$	15.9535	0.9620
$\ln K_{i,t}$	17.1079	0.9935
$\ln L_{i,t}$	12.2875	0.9709
$\ln R_{i,t}$	3.1233	14.7020
$\ln n_{i,t}$	10.4960	0.9936
$p_{i,t,1}$ [HT]	0.0131	0.0049
$p_{i,t,2}$ [MT]	0.0108	0.0046
$p_{i,t,3}$	0.9760	0.0078
Observations	572.0000	

Source: INE

Table 3a. Estimation of Equation (11): Dependent Variable - $\ln \overline{Y}_{i,t}$

Independent Variables	*Coefficient*	**Model 1**		*Coefficient*	**Model 2**		*Coefficient*	**Model 3**	
Constant		6.0725	***		6.0972	***		8.0188	***
		[0.000]			[0.000]			[0.000]	
$\ln K_{i,t}$	α	0.2170	***		0.1822	***		0.1804	***
		[0.000]			[0.000]			[0.000]	
$\ln L_{i,t}$	β	0.2126	***		0.1860	***		0.1875	***
		[0.000]			[0.000]			[0.000]	
$\ln R_{i,t}$	μ	0.0103	***		0.0120	***		0.0098	***
		[0.007]			[0.003]			[0.008]	
$\ln E_{i,t}$	δ	-0.2347	***	δ_F	-0.2605	***	δ_3	-0.5207	***
		[0.000]			[0.000]			[0.000]	
$\ln E_{i,t-1}$				δ_T-δ_F	0.0496				
					[0.430]				
$\ln E_{i,t1}$ [HT]							δ_1-δ_3	0.3582	***
								[0.000]	
$\ln E_{i,t2}$ [MT]							δ_2-δ_3	0.1188	**
								[0.019]	
Observations		572.0000			520.0000			572.0000	
Groups: Provinces		52.0000			52.0000			52.0000	
R-squared within		0.7447			0.6632			0.7600	
R-squared between		0.9810			0.9807			0.9853	
R-squared overall		0.9799			0.9797			0.9835	

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Standard errors are in brackets. Regional fixed effects estimations.

Table 3b. Estimation of Equation (11): Dependent Variable - $\ln Y_{i,t}$

Independent Variables	*Coefficient*	**Model 1**		*Coefficient*	**Model 2**		*Coefficient*	**Model 3**	
Constant		6.0725	***		6.0972	***		8.5685	***
		[0.000]			[0.000]			[0.000]	
$\ln K_{i,t}$	α	0.2170	***		0.1822	***		0.1981	***
		[0.000]			[0.000]			[0.000]	
$\ln L_{i,t}$	β	0.2126	***		0.1860	***		0.2554	***
		[0.000]			[0.000]			[0.000]	
$\ln R_{i,t}$	μ	0.0103	***		0.0120	***		0.0106	***
		[0.007]			[0.003]			[0.004]	
$\ln E_{i,t}$	δ_{CRS}	0.3357	***	δ_F	0.3713	***			
		[0.000]			[0.000]				
$\ln E_{i,t-1}$				δ_T-δ_F	0.0496				
					[0.430]				
$\ln E_{i,t1}$ [HT]							δ_1	0.1349	***
								[0.000]	
Observations		572.0000			520.0000			572.0000	
Groups: Provinces		52.0000			52.0000			52.0000	
R-squared within		0.7447			0.6632			0.7600	
R-squared between		0.9810			0.9807			0.9853	
R-squared overall		0.9799			0.9797			0.9835	

*: Significant at the 0.10 level. **: Significant at the 0.05 level. ***: Significant at the 0.01 level. Standard errors are in brackets. Regional fixed effects estimations.