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Entrepreneurship Capital and Regional Productivity Revisited*

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Abstract

Entrepreneurship capital has been considered in the literature to be a public good, so it will positively affect the total factor productivity of the firms in a certain region. There is evidence confirming a positive relationship between entrepreneurship capital measures and regional production. This paper argues that this evidence could also be explained by the presence of decreasing returns to scale in firms' production technology. So previous evidence may be mixing both effects: returns to scale and public goods. This paper provides a simple methodological benchmark for distinguishing between and measuring both effects. The analysis conducted using a sample of 52 Spanish provinces for eleven years confirms the presence of decreasing returns to scale. In our data, previous interpretations of the evidence overestimate the effect of regional entrepreneurship capital as a public good 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, 2004b, 2004c, 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 even if firms in different regions are equally productive, the number of firms in the region will be positively related with the region's production level when the firms' technology has decreasing returns to scale. 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 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 paper. 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) or Qian et al., (2013) among others 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. Several papers (Delgado et al. 2010; Maskell and Malmberg 2007; Storper and Venables 2004; Gertler 2003) have analyzed different mechanisms people find to overcome such filters and find ways of using the knowledge to produce commercial goods and become 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; Bönnte 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, 2004b,

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 Bönnte 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:

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

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 $\varepsilon_{i,t}$ 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:

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

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; Bönnte 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, 2004b, 2004c, 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) or (2). They do not analyze 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 Aggregated data at the regional level and the firms' production functions

The reviewed literature can be considered a stream of a broader literature on the determinants of regional production (Solow, 1956; Romer, 1986) from which we would not like to depart. Regional production is the aggregation of firms' production in the region. But collecting information at the firm level would be extremely demanding in terms of data. So 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, as the literature reviewed in the previous section has done, such assumptions are not as innocuous as

they might be for other research purposes.

Let us focus first on the implications of considering entrepreneurship capital as a public good in the production function of one firm. Define $Y_{j,i,t}$ as the production of firm j in region i during period t . Firm j can use a set of private inputs purchased on the market and a set of public goods available in region i . To reduce notation and be consistent with previous literature consider only capital ($K_{j,i,t}$) and labour ($L_{j,i,t}$) as private inputs and knowledge ($R_{i,t}$) and entrepreneurship capital ($E_{i,t}$) as public goods at regional level. The following function summarizes the relationship between the production and inputs used:

$$Y_{j,i,t} = TFP_{j,i,t} f(K_{j,i,t}, L_{j,i,t}) e^{v_{j,i,t}} = g(R_{i,t}, E_{i,t}) f(K_{j,i,t}, L_{j,i,t}) e^{a_{j,i,t} + v_{j,i,t}} \quad (3)$$

The parameter $a_{j,i,t}$ captures persistent differences in the total factor productivity ($TFP_{j,i,t} = g(R_{i,t}, E_{i,t}) e^{a_{j,i,t}}$) between firms and $v_{j,i,t}$ are independently distributed error terms. To be consistent with the previous literature we will assume that g and f are Cobb-Douglas functions, $g(R_{i,t}, E_{i,t}) = R_{i,t}^{\mu} E_{i,t}^{\delta}$ and $f(K_{j,i,t}, L_{j,i,t}) = K_{j,i,t}^{\alpha} L_{j,i,t}^{\beta}$. For most of our argumentations we will only require function f to be homogenous at degree θ . Remind that the Cobb-Douglas is a homogenous function of degree $\theta = \alpha + \beta$. If the entrepreneurship capital is a public good, it will be expected that $\partial g / \partial E > 0$ or in terms of the Cobb-Douglas parameters' functions $\delta > 0$.

As commented earlier, collecting information at the firm level would be extremely demanding. So the information that is usually available is the aggregation of the production, $Y_{i,t}$, labor, $L_{i,t}$, and capital $K_{i,t}$ of the $n_{i,t}$ firms operating in region i during period t . So in order to interpret the estimations made by the reviewed literature in terms of the parameters of Equation (3), further assumptions are needed. To analyze such assumptions, let us define $\bar{Y}_{i,t}$ as the average production in a certain region i and period t , $\bar{Y}_{i,t} = \sum_{j=1}^{n_{i,t}} Y_{j,i,t} / n_{i,t}$ and $\bar{y}_{j,i,t}$ as the ratio between the production of one firm and the average for the region, $\bar{y}_{j,i,t} = Y_{j,i,t} / \bar{Y}_{i,t}$.

Likewise, we can define $\bar{K}_{i,t} = \sum_{j=1}^{n_{i,t}} K_{j,i,t} / n_{i,t}$, $\bar{L}_{i,t} = \sum_{j=1}^{n_{i,t}} L_{j,i,t} / n_{i,t}$, $\bar{k}_{j,i,t} = K_{j,i,t} / \bar{K}_{i,t}$ and $\bar{l}_{j,i,t} = L_{j,i,t} / \bar{L}_{i,t}$. Then we can relate the production and inputs used by one firm with the production and inputs used in the region in the following way: $Y_{j,i,t} = \bar{y}_{j,i,t} Y_{i,t} / n_{i,t}$, $L_{j,i,t} = \bar{l}_{j,i,t} L_{i,t} / n_{i,t}$ and $K_{j,i,t} = \bar{k}_{j,i,t} K_{i,t} / n_{i,t}$. Given that f is homogenous at degree θ and the definitions above, Equation (3) can be rewritten as:

$$Y_{j,i,t} = \bar{y}_{j,i,t} Y_{i,t} / n_{i,t} = n_{i,t}^{\theta} g(R_{i,t}, E_{i,t}) f(\bar{k}_{j,i,t} K_{i,t}, \bar{l}_{j,i,t} L_{i,t}) e^{a_{j,i} + v_{j,i,t}} \quad (4)$$

Note that the aggregated data does not allow us to distinguish among firms. So assumptions have to be made about some parameters, more concretely: $a_{j,i} = a_i$, and $\bar{y}_{j,i,t} = \bar{l}_{j,i,t} = \bar{k}_{j,i,t} = 1$. The first assumption is that firm fixed effects are the same for all the firms in one region. The second assumption implies that all the firms in the region are of the same size in terms of outputs and inputs. Obviously this is not the case in most regions, but if the distribution of firm sizes around the average is fairly constant over time, these effects will be captured by the regional fixed effect, a_i . Under these assumptions, using Cobb-Douglas functions in Equation (4) and taking logarithms, we obtain:

$$\ln \bar{Y}_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln \bar{K}_{i,t} + \beta \ln \bar{L}_{i,t} + a_i + \varepsilon_{i,t} \quad (5)$$

or what is exactly the same:

$$\ln Y_{i,t} = (1 - \alpha - \beta) \ln n_{i,t} + \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln K_{i,t} + \beta \ln L_{i,t} + a_i + \varepsilon_{i,t} \quad (6)$$

where $\varepsilon_{i,t} = \sum_{j=1}^{n_{i,t}} v_{j,i,t} / n_{i,t}$.

The reviewed literature has estimated Equation (1), which can be deduced from Equation (5 or 6) when a new assumption is introduced, $n_{i,t} = 1$. The region is considered to be a unit of production. This assumption could be understandable when there is no information about the number of firms in the regions analyzed, but not when most of the entrepreneurship capital measures used previously in the literature are based on the number of firms. Obviously, one could argue that this assumption is irrelevant because technologies usually present constant returns, $\theta = \alpha + \beta = 1$, but this is not the case in the studies analyzed.

For the sake of simplicity, let us assume that the entrepreneurship capital is measured by the number of firms, $E_{i,t} = n_{i,t}$. It is easy to check that Equation (1) and Equation (5 or 6) will provide the same estimation of all the parameters except for parameter δ . To differentiate between them, we will use δ_{CRS} to refer to the parameter estimated by

Equation (1), and δ for that estimated by Equation (5 or 6), where $\delta_{CRS} = 1 - \alpha - \beta + \delta$. So those parameters will be equal when there are constant returns to scale. Note that if this is not the case, the production has decreasing returns to scale, and the regions only differ in the number of firms (the firms in all the regions are equally productive, $\mu = \delta = 0$, $a_{i,t} = a$, and are of the same average size, $(\bar{K}_{i,t} = \bar{K}_t, \bar{L}_{i,t} = \bar{L}_t)$) the effect of entrepreneurship capital estimated by Equation (1) will be positive, $\delta_{CRS} = 1 - \alpha - \beta > 0$.

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 ($\delta_{CRS} > 0$) for two reasons. First, the firms are smaller (in terms of the private inputs used) and the production has decreasing returns to scale $\theta = \alpha + \beta < 1$. Second, the number of firms is a proxy or a measure of a public good ($\delta > 0$).

The relationship between entrepreneurship capital and production ($\delta_{CRS} > 0$) 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, but evidence is needed to disentangle the causes: i) there are decreasing returns to scale ($\theta = \alpha + \beta < 1$) and/or ii) the number of firms affects the productivity of the firms in the region ($\delta > 0$).

Our proposal is to look in more depth at these two possible causes. A priori we do not know which is the case, and it could in fact vary among different entrepreneurship capital measures. The discussion above could be reformulated in terms of endogeneity, where the omitted variable is the stock of firms. In Equation (1), the error term $((1 - \alpha - \beta) \ln n_{i,t} + \varepsilon_{i,t})$ is expected to be correlated with the entrepreneurship capital measure, $\ln E_{i,t}$. The bias 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 solution is simply to introduce to the regressions the omitted variable, stock of firms (which is available in most of the studies reviewed in the

section above), restricting its coefficient to $(1 - \alpha - \beta)$. In other words, estimate Equation (6), or what is the same, Equation (5). 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 related 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. The problem is not measuring entrepreneurship capital, it is omitting a relevant variable from the estimations, the number of firms. In accordance with the discussion in the previous section, this is solved by estimating Equation (5), i.e. using the number of firms to compute the average production $(\bar{Y}_{i,t})$ and private inputs $(\bar{K}_{i,t}, \bar{L}_{i,t})$ used as variables in the cited equation:

$$\ln \bar{Y}_{i,t} = \mu \ln R_{i,t} + \delta \ln E_{i,t} + \alpha \ln \bar{K}_{i,t} + \beta \ln \bar{L}_{i,t} + a_i + \varepsilon_{i,t} \quad (7)$$

This formulation enables us to decompose the effect of entrepreneurship capital on production estimated by Equation (1) (δ_{CRS}) into two components: i) the presence of decreasing returns to scale ($\theta = \alpha + \beta < 1$) and ii) the effect of entrepreneurship capital as a public good ($\delta > 0$).

In fact, a priori, we can not exclude the possibility of increasing returns to scale in production technologies ($\theta > 1$). In this case, previous methods (Equation (1)) will underestimate the effect of the entrepreneurship capital on the firms' productivity ($\delta_{CRS} = 1 - \alpha - \beta + \delta$). So our first proposal is to test a hypothesis that we expect to reject, the presence of constant returns to scale. In other words, that the coefficients estimated by Equation (1) and (5) will be the same ($\delta_{CRS} = \delta$).

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

The rejection of this hypothesis will confirm the need to estimate Equation (5) in order to estimate the effect of entrepreneurship capital as a public good ($\delta > 0$).

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

Obviously the interpretation of this parameter is made under the assumptions described in the previous section, which are related with the kind of data available. In the cited section, the size of the firms is exogenously determined, or more concretely, this is unrelated with the total factor productivity of the firm.

Some microeconomic literature has 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). When more talented entrepreneurs start and manage bigger firms, then the total factor productivity is positively correlated with firm's size. Leung et al., (2008) and Castany et al., (2005) provide evidence in this regard.

After controlling by the volume of inputs those regions with a lower number of firms will also be those with higher average firm size. In accordance with these models, the larger size of the firms is interpreted as a proxy of a higher average talent of firm managers. Consequently, a higher productivity of the firms is expected in those regions with a lower number of firms. This stream of literature predicts that the value of parameter δ will be negative. Note that $\delta < 0$ could be consistent with the evidence described in Section 2, $\delta_{CRS} > 0$, as long as: $1 - \alpha - \beta > -\delta > 0$. In fact both explanations, entrepreneurship capital as a public good and differences in entrepreneur's talent, are not exclusive. Disaggregate information at the firm level could help to distinguish between them. 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 ($s=1, \dots, S$) 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 . Then we 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 $b_{i,t} = 0$, then the introduction of all this nomenclature does not make much sense. 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:

$$\ln \bar{Y}_{i,t} = \mu \ln R_{i,t} + \delta_S E1_{i,t} + \sum_{s=1}^{S-1} (\delta_s - \delta_S) E1_{i,t,s} + \alpha \ln \bar{K}_{i,t} + \beta \ln \bar{L}_{i,t} + a_i + \varepsilon_{i,t} \quad (8)$$

Therefore Equation (5) 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 $\bar{\delta}_s$ as the parameter estimated by Audretsch and Keilbach's (2004a,b,c, 2008) procedure, and δ_s the one estimated using Equation (7). Let us assume that we are in a situation where the sectorial decomposition is irrelevant ($\delta_s = \delta$ 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 $\bar{\delta}_s = \delta_s/p_s$ given that $E1_{i,t,s} = p_s E1_{i,t}$. So in this case the estimated parameter $\bar{\delta}_s$ 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 ($\delta_s = \delta$ 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 (7) has similar problems to that detected in the section above related to the parameter δ estimated by Equation (5).

Entrepreneurship capital has a scale effect, δ estimated in Equation (5), and a sectorial composition effect, δ_s estimated in Equation (7) by the introduction of $p1_{i,t,s}$. Previous literature (Audretsch and Keilbach, 2004a, 2004b, 2004c, 2008) assumes that the total factor productivity of firms, on average, does not differ among sectors. 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 aggregated total factor productivity of the region could depend on the weight of the different economic sectors. 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 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 between sectors.

6 Data and Variables

The purpose of the empirical exercise is to provide insights into the magnitude and implications of the problems highlighted in the previous sections. For this purpose we are going to provide estimations of Equation (7), where the dependent variable is the firms' average annual 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 for other possible sources of endogeneity already not considered in the reviewed literature. Given our comparative purpose, the current evidence and theoretical debate, it is difficult to figure out the nature of those relationships and then analyse other sources of endogeneity. We created panel data covering an eleven-year period from 2002 to 2012 ($t = 1, \dots, 11$), for the 52 Spanish provinces ($i = 1, \dots, 52$), 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 (7):

$$\delta \ln E_{i,t} = \delta_F \ln(1 + \phi_{i,t}) + \delta_T \ln n_{i,t-1} = \delta_F \ln n_{i,t} + (\delta_T - \delta_F) \ln n_{i,t-1} \quad (9)$$

and interpret Equation (7) 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 rate. In short, the number of firms is needed to estimate Equation (7). 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 Bönnte 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 3 provides estimations of Equation (7). The columns differ in terms of the entrepreneurship capital measures used in the estimations, or in other words, the different restrictions imposed on the parameters of the equation. In Model 1 only considers the number of firms in the region, providing estimations of δ . Model 2 also includes the last year's stock of firms providing estimations of δ_F and δ_T . Model 3 decomposes the current stock of firms into economic sectors providing estimations of δ_s .

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 Breusch 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 analyzed¹. The error terms of all the estimated equations are robust to heteroskedasticity and clustered by provinces.

Table 3 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 at the usual levels of significance².

¹This 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.

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

Model 1 presents the estimation of Equation [7] without any decomposition of the entrepreneurship capital. In concordance with the presence of decreasing returns to scale, the estimations of the elasticity of production with respect to entrepreneurship capital using Equation (1), as was usual in previous empirical studies, ($\delta_{CRS} = 1 - \alpha - \beta + \delta = 0.3357$) is higher than the one estimated by Equation (7), ($\delta = -0.2347$). We do not present the estimation of Equation [1] because it only differs from Equation [7] in the value of the cited parameter, which in both estimations is statistically significant at the 1% level. According to the results above, and consistent with the previous literature, 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. But, the main explanation for those effects is the existence of decreasing returns to scale ($1 - \alpha - \beta = 0.5704$). In fact, according to Equation (7), the productivity of the average firm decreases by a percentage of 0.2347% for each 1% increase in the number of firms in the province. So Hypothesis 2 is not supported by the data. Note that the traditional methods (Equation (1)) would lead to the opposite conclusion.

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. 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 ($\delta_T - \delta_F = 0.0496$). The effect estimated for the flow of firms in the previous year ($-0.2605 = \delta_F$) is even more negative than the one associated with the stock of firms ($-0.2109 = \delta_T$).

Model 3 in Table 3 provides estimations of Equation (7) 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 ($\delta_1 = -0.1625$) is higher than the one associated with high and medium tech manufacturing firms ($\delta_2 = -0.4019$) and other sectors ($\delta_3 =$

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

-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.

Table 4 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, 2004b, 2004c, 2008). The results are consistent with those obtained previously in the literature. As opposed to Model 3 in Table 3, 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: for each region, the regressions use the firms' average output and private inputs. 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		<i>s=1</i>
	721 Research and experimental development on natural sciences and engineering		<i>s=1</i>
	722 Research and experimental development on social sciences and humanities	Very high	<i>s=1</i>
59	Motion picture, video & TV production, sound recording & music publishing act.	tech services	<i>s=1</i>
60	Programming and broadcasting activities	sectors	<i>s=1</i>
61	Telecommunications	[HT]	<i>s=1</i>
62	Computer programming, consultancy and related activities		<i>s=1</i>
63	Information service activities		<i>s=1</i>
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations		<i>s=2</i>
26	Manufacture of computer, electronic and optical products		<i>s=2</i>
	303 Manufacture of air and spacecraft and related machinery	High & medium	<i>s=2</i>
20	Manufacture of chemicals and chemical products	tech	<i>s=2</i>
25	Manufacture of fabricated metal products, except machinery and equipment	manufacturing	<i>s=2</i>
27	Manufacture of electrical equipment	sectors	<i>s=2</i>
29	Manufacture of motor vehicles, trailers and semi-trailers	[MT]	<i>s=2</i>
30	Manufacture of other transport equipment		<i>s=2</i>
	325 Manufacture of medical and dental instruments and supplies		<i>s=2</i>
	Remaining sectors	[NT]	<i>s=3</i>

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	1.4702
$\ln n_{i,t}$	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	

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

Independent Variables	Coefficient	Model 1		Model 2		Model 3	
		Coefficient		Coefficient		Coefficient	
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]	
$\ln E_{i,t-1}$			$\delta_T - \delta_F$	0.0496			
				[0.430]			
$\ln E_{i,t1}$ [HT]					$\delta_1 - \delta_3$	0.3582 ***	
						[0.000]	
$\ln E_{i,t2}$ [MT]					$\delta_2 - \delta_3$	0.1188 **	
						[0.019]	
Observations		572.0000		520.0000		572.0000	
Groups: Provinces		52.0000		52.0000		52.0000	
R-squared within		0.3436		0.3073		0.3981	
R-squared between		0.1442		0.1493		0.1427	
R-squared overall		0.1446		0.1495		0.1422	

*: 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		Model 2		Model 3	
		Coefficient		Coefficient		Coefficient	
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]			
$\ln E_{i,t-1}$			$\delta_T - \delta_F$	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.